THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

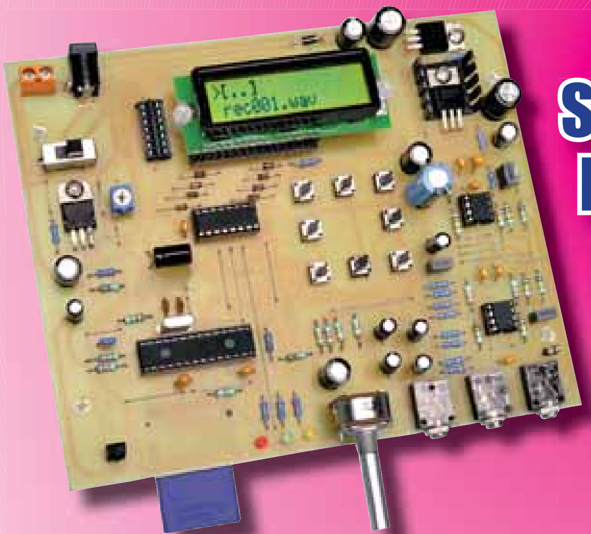
EPE EVERYDAY PRACTICAL ELECTRONICS

www.epemag.com

WIN A MICROCHIP MPLAB Starter Kit

DELUXE 3-CHANNEL UHF ROLLING CODE REMOTE CONTROL

High-security UHF transmitter/receiver for keyless entry, garage door or lighting control



SD CARD MUSIC & SPEECH RECORDER/PLAYER

- Free-standing recorder, or works with Windows, Mac or Linux PC
- Use as a jukebox or sound effects player

INPUT ATTENUATOR FOR THE DIGITAL AUDIO MILLIVOLTMETER

An add-on project for measuring AC voltages to 140V RMS

PLUS

TEACH-IN 2011 – PART 10

Construction and testing

$8.99US £4.25UK
AUGUST 2011 PRINTED IN THE UK
08
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Low-Power Microcontrollers for Battery-Friendly Design

Microchip Offers Lowest Currents for Active and Sleep Modes

Extend the battery life in your application using PIC® microcontrollers with nanoWatt XLP Technology and get the industry's lowest currents for Active and Sleep modes.

Microchip's new peripheral-rich PIC12F182X, PIC16F182X and PIC16F19XX families offer active currents of less than 50 µA and sleep currents down to 20 nA. These products enable you to create battery-friendly designs that also incorporate capacitive touch sensing, LCD, communications and other functions which help differentiate your products in the marketplace.

Microchip's Enhanced Mid-range 8-bit architecture provides up to 50% increased performance and 14 new instructions that result in up to 40% better code execution over previous-generation 8-bit PIC16 MCUs.

PIC12F182X and PIC16F182X families include:

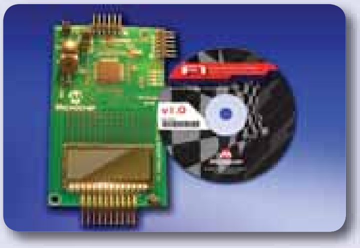
- Packages ranging from 8 to 64 pins
- mTouch™ capacitive touch-sensing
- Multiple communications peripherals
- Dual I²C™/SPI interfaces
- PWM outputs with independent time bases
- Data signal modulator

PIC16F19XX family includes:

- mTouch capacitive touch-sensing
- LCD drive
- Multiple communications peripherals
- More PWM channels, with independent timers
- Up to 28 KB of Flash program memory
- Enhanced data EEPROM
- 32-level bandgap reference
- Three rail-to-rail input comparators

GET STARTED IN 3 EASY STEPS

1. View the Low Power Comparison videos
2. Download the Low Power Tips 'n Tricks
3. Order samples and development tools
   www.microchip.com/XLP



PIC16F193X 'F1' Evaluation Platform - DM164130-1

Intelligent Electronics start with Microchip

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www.microchip.com/xlp

MICROCHIP

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• PROJECTS • THEORY •
• NEWS • COMMENT •
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VOL. 40. No 8 Aug 2011

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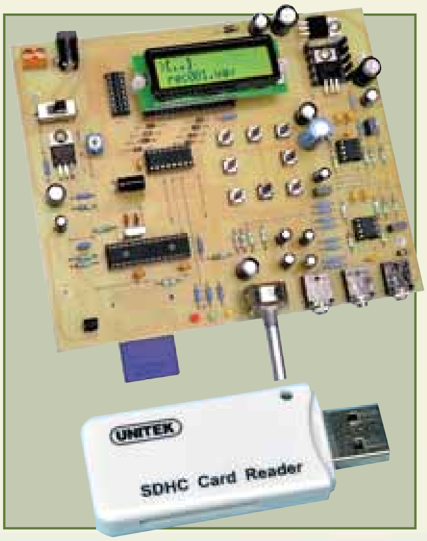


Projects and Circuits

Series and Features

Regulars and Services

Our September 2011 issue will be published on Thursday 11 August 2011, see page 80 for details.

CELEBRATING 30 YEARS OF SERVICE

Everyday Practical Electronics FEATURED KITS

AUGUST 2011

Everyday Practical Electronics Magazine has been publishing a series of popular kits by the acclaimed Silicon Chip Magazine Australia. These projects are 'bullet proof' and already tested Down Under. All Jaycar kits are supplied with specified board components, quality fibreglass tinned PCBs and have clear English instructions. Watch this space for future featured kits.

240V 10A Deluxe Motor Speed Controller Kit

KC-5478 £36.25 plus postage & packing

The deluxe motor speed controller kit allows the speed of a 240VAC motor to be controlled smoothly from near zero to full speed. The advanced design provides improved speed regulation & low speed operation. Also features soft-start, interferences suppression, fuse protection and over-current protection. Kit supplied with all parts including pre-cut metal case.

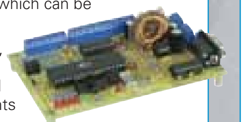
Note: Requires UK mains socket or adaptor

Featured in EPE May 2011

SMS Controller Module

KC-5400 £21.25 plus postage & packing

Control appliances or receive alert notification from anywhere. By sending plain text messages this kit will allow you to control up to eight devices. At the same time, it can also monitor four digital inputs. It works with old Nokia handsets such as the 5110, 6110, 3210, and 3310, which can be bought inexpensively.



- Kit supplied with PCB, pre-programmed microcontroller and all electronics components with manual
- Requires a Nokia data cable which can be readily found in mobile phone accessory stores

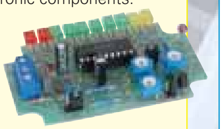
Featured in EPE: March 2007

Automotive Kits

Voltage Monitor Kit

KC-5424 £8.50 plus postage & packing

This versatile kit will allow you to monitor the battery voltage, the airflow meter or oxygen sensor in your car. The kit features 10 LEDs that illuminate in response to the measured voltage, preset 9-16V, 0.-5V or 0-1V ranges, complete with a fast response time, high input impedance and auto dimming for night time driving. Kit includes PCB with overlay, LED bar graph and all electronic components.



- PCB: 74 x 47mm
- 12VDC

Featured in EPE September 2010

Ignition Kit

KC-5442 £34.50 plus postage & packing

This advanced and versatile ignition system is suited for both two & four stroke engines. Used to modify the factory ignition timing or as the basis for a stand-alone ignition system with variable ignition timing, electronic coil control and anti-knock sensing (available separately).

- Timing retard & advance over a wide range
- Suitable for single coil systems
- Dwell adjustment
- Single or dual mapping ranges
- Max & min RPM adjustment
- Kit includes PCB with overlay, programmed micro, all electronic compontents and die cast box

Featured in EPE November 2009

Water Tanks Kits

PIC Based Water Tank Level Meter Kit

KC-5460 £39.50 plus postage & packing

This PIC-based unit uses a pressure sensor to monitor water level and will display tank level via an RGB LED at the press of a button. The kit can be expanded to include and optional wireless remote display panel that can monitor up to ten separate tanks (KC-5461) or you can add a wireless remote controlled mains power switch (KC-5462) to control remote water pumps. Kit includes electronic components, case, screen printed PCB & pressure sensor.

Featured in EPE May 2010

Also available: KC-5461 Remote display kit £31.00

Remote Control Mains Switch Kit

KC-5462 £36.25 plus postage & packing

Commercial remote control mains switches are available but these are generally limited to a range of less than 20m. This UHF system will operate up to 200m and is perfect for remote power control systems etc. The switch can be activated using the included hand held controller. Kit supplied with case, screen printed PCB, RF modules and all electronic components.

Note: Requires UK mains socket or adaptor.

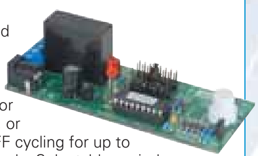
Featured in EPE May 2010

Hand held remote control!

Low Cost Programmable Interval Timer

KC-5464 £12.75 plus postage & packing

Here's a new and completely updated version of the 'Flexitimer' shown to the right. It is link programmed for either a single ON, or continuous ON/OFF cycling for up to 48 on/off time periods. Selectable periods are from 1 to 80 seconds, minutes, or hours and it can be restarted at any time. Kit includes PCB and all specified electronic components.



- Power requirement: 12VDC
- PCB Dimensions: 102 x 42mm

Featured in EPE August 2010

The 'Flexitimer' Timer Kit

KA-1732 £7.25 plus postage & packing

This kit uses a handful of components to accurately time intervals from a few seconds to a whole day. It can switch a number of different output devices and can be powered by a battery or mains plugpack.

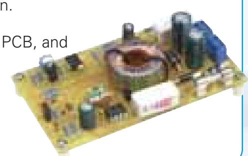
- Kit includes PCB and all components
- Power requirement 12 - 15VDC

Featured in EPE May/June 2008

Luxeon Star LED Driver Kit

KC-5389 £11.00 plus postage & packing

Luxeon high power LEDs are some of the brightest LEDs available in the world. They offer up to 120 lumens per unit, and will last up to 100,000 hours! This kit allows you to power the fantastic 1W, 3W, and 5W Luxeon Star LEDs from 12VDC. This means that you can take advantage of what these fantastic LEDs have to offer, and use them in your car, boat, or caravan.



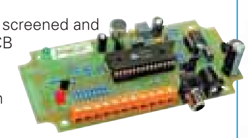
- Kit supplied with PCB, and all electronic components

Featured in EPE April 2007

45 Second Voice Recorder Module

KC-5454 £16.00 plus postage & packing

This kit has been improved and can now be set up easily to record two, four or eight different messages for random-access playback or a single message for 'tape mode' playback. Also, it now provides cleaner and glitch-free line-level audio output suitable for feeding an amplifier or PA system. It can be powered from any source of 9-14V DC.



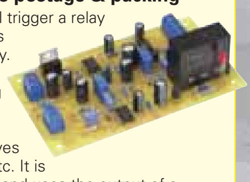
- Supplied with silk screened and solder masked PCB and all electronic components.
- PCB: 120 x 58mm

Featured in EPE February 2011

Delta Throttle Timer Kit

KC-5373 £9.25 plus postage & packing

This brilliant design will trigger a relay when the accelerator is pressed or lifted quickly. Used for automatic transmission switching of economy to power modes or trigger electronic blow-off valves on quick throttle lifts etc. It is completely adjustable, and uses the output of a standard throttle position sensor.

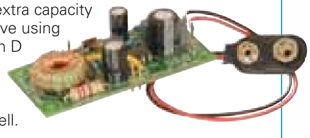


Featured in EPE November 2006

3V to 9V DC to DC Converter Kit

KC-5391 £6.00 plus postage & packing

This great little converter allows you to use regular Ni-Cd or Ni-MH 1.2V cells, or Alkaline 1.5V cells for 9V applications. Using low cost, high capacity rechargeable cells, the kit will pay for itself in no-time! You can use any 1.2-1.5V cells you desire. Imagine the extra capacity you would have using two 9000mAh D cells in replacement of a low capacity 9V cell.



- PCB Dimensions: 59 x 29mm

Featured in EPE June 2007

Jaycar Electronics

Freecall order: 0800 032 7241

Best Selling Kits for Electronic Enthusiasts

KIT OF THE MONTH

Ultrasonic Antifouling Kit for Boats

KC-5498 £90.50 plus postage & packing

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in sturdy polyurethane housings. By building yourself (which includes some potting) you save a fortune! Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring. (Price includes epoxies).

Don't just sit there BUILD SOMETHING!

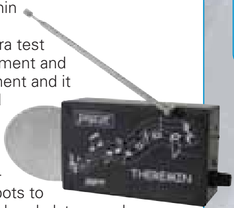
- 12VDC
- Suitable for power or sail
- Could be powered by a solar panel/ wind generator
- PCB: 78 x 104mm

Best Seller

Theremin Synthesiser Kit MkII

KC-5475 £27.25 plus postage & packing

The ever-popular Theremin is better than ever. It's easier to set up with extra test points for volume adjustment and power supply measurement and it now runs on AC to avoid the interference switchmode plugpacks can cause. It's also easier to build with PCB-mounted switches and pots to reduce wiring to just the hand plate, speaker and antenna and has the addition of a skew control to vary the audio tone from distorted to clean.



- Complete kit contains PCB with overlay, pre-machined case and all specified components

SLA Battery Health Checker Kit

KC-5482 £29.00 plus postage & packing

The first versions of the battery zapper included a checker circuit. The Mk III battery zapper (KC-5479) has a separate checker circuit - and this is it. It checks the health of SLA batteries prior to charging or zapping with a simple LED condition indication of fair, poor, good etc.

- Overlay PCB and electronic components
- Case with machined and silk-screened front panel
- PCB Dimensions: 185 x 101mm

SD/MMC Card Webserver Kit in a Box

KC-5489 £32.75 plus postage & packing

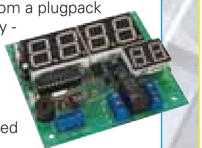
Host your own website on a common SD/MMC card with this compact Web server In a Box (WIB). Connecting to the Internet via your modem/router, it features inbuilt HTTP server, FTP server, SMTP email client, dynamic DNS client, RS232 serial port, four digital outputs and four analogue inputs. Requires a SD memory card, some SMD soldering and a 6-9VDC adaptor. Kit includes PCB, case and electronic components.

- PCB Dimensions: 123 x 74mm

Remote Control Digital Timer Kit

KC-5496 £14.50 plus postage & packing

Remote-controlled digital timer with a bright 20mm-high 7-segment red LED display. It can count up or down from one second to 100 hours in 1-second increments. Its timing period can either be set and controlled using the remote control or it can be automatically controlled via external trigger/reset inputs. An internal relay and buzzer activate when the unit times out. The relay contacts can be used to switch devices rated up to 30VDC or 24VAC and the project can be powered from a plugpack or a battery. Short form kit only - you'll need to add your own universal remote, power supply and enclosure.

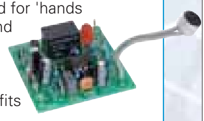


- 9-12VDC @300mA
- PCB and components included

"Minivox" Voice Operated Relay Kit

KC-5172 £6.00 plus postage & packing

Voice operated relays are used for 'hands free' radio communications and some PA applications etc. Instead of pushing a button, this device is activated by the sound of a voice. This tiny kit fits in the tightest spaces and has almost no turn-on delay. 12VDC @ 35mA required. Kit is supplied with PCB electret mic, and all specified components.



- PCB Dimensions: 47 x 44mm

Audio Amplifier Kits

"The Champ" Audio Amplifier Kit

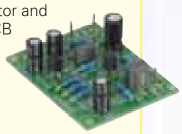
KC-5152 £3.00 plus postage & packing

This tiny module uses the LM386 audio IC, and will deliver 0.5W into 8 ohms from a 9 volt supply making it ideal for all those basic audio projects. It features variable gain, will happily run from 4-12VDC and is smaller than a 9 volt battery, allowing it to fit into the tightest of spaces. PCB & all electronic components included.

"Pre-Champ" Versatile Preamplifier

KC-5166 £3.50 plus postage & packing

Designed to be used with the 'Champ' amplifier KC-5152. Unless you have a signal of sufficient amplitude the 'Champ' will not produce its maximum power output. The 'Pre-Champ' is the answer with a gain in excess of 40dB, which is more than enough for most applications. You can vary the gain by changing a resistor and there is even provision on the PCB for an electret microphone.

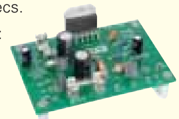


- Power requirement 6 - 12VDC
- Kit includes PCB and electronic components

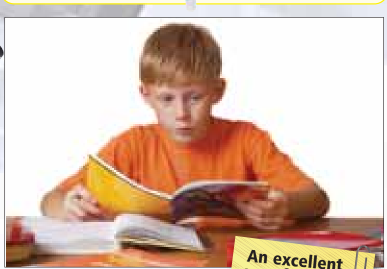
50 Watt Amplifier Module

KC-5150 £11.00 plus postage & packing

This 50 watt unit uses a single chip module and provides 50WRMS @ 8 ohms with very low distortion. PC Board and all electronic components supplied. Requires heatsink. See website for full specs.



- PCB Dimensions: 84 x 58mm
- Heatsink to suit HH-8590 £7.00



SHORT CIRCUITS - VOLUME 1

An excellent way for new comers to dip their toes into the wonders of electronics!

This volume will teach you everything you need to get started in electronics and is suitable for ages 8+. We give you the option of buying the book on its own, or together with the accompanying kit that contains the components for each of the 20-odd projects described in the book. Some of the exciting projects include a Police Siren, Electronic Organ, Sound Effects Unit, Light Chaser and many, many more! The full colour 96 page book, is lavishly illustrated with over 100 drawings and diagrams. No prior knowledge of electronics is needed, projects are fun and totally safe to build.

MORE INFO AVAILABLE ONLINE

AGES 8+

Short Circuits Book
BJ-8502 £3.75

Short Circuits Project Kit
KJ-8504 £12.50

Short Circuits Book and Project Kit
KJ-8502 £16.50

Post & Packing Charges

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£10 - £49.99	£5
£50 - £99.99	£10
£100 - £199.99	£20
£200 - £499.99	£30
£500+	£40
Max weight 12lb (5kg)	
Heavier parcels POA	
Minimum order £10	

Note: Products are despatched from Australia, so local customs duty & taxes may apply.

- **All pricing in Pounds Sterling**
- **Minimum order £10**

Prices valid until 31/8/2011

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*Australian Eastern Standard Time
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All modules assembled & tested.
Digital Echo Chamber Kit
A compact sound effects kit, with built-in mic or line in, line out or speaker (500mW). 4 Adjustment controls
Power: 9Vdc 150mA
MK182 Velleman kit £11.43
Digital Record/Player
Non volatile flash memory, Single 20 sec recording via integral mic, 2W output to 8Ω speaker.
Power: 5Vdc 100mA
C-9701 Cebek Module £7.89
3rd Brake Light Flasher Kit
Works with any incandescent or LED rear centre brake light. Flashes at 7Hz for 5 or 10 times, adjustable re-triggering.
Power: 12Vdc max load 4A
MK178 Velleman kit £6.30
Multifunction Up/Down Counter
An up or down counter via on-board button or ext input. Time display feature. Alarm count output. 0-9999 display.
Power: 9-12Vdc 150mA
K8035 Velleman kit £17.85
2 Digital Counter
Standard counter, 0 to 99 from input pulses or external signal. With reset input, 13.5mm Displays,
Power: 12Vdc 90mA.
CD-9 Cebek Module £12.99
Digital Clock Mini Kit
Red 7 Segment display in attractive enclosure, automatic time base selection, battery back-up, 12 or 24Hr modes.
Power: 9Vac or dc
MK151 Velleman kit £15.09
Nixie Clock Kit
Gas filled nixie tubes with their distinctive orange glow. HH:MM display, automatic power sync 50/60Hz
Power: 9-12Vac 300mA
K8099 Velleman kit £64.96
1.8W Mono Amplifier
Compact mono 1.8W RMS 4Ω power stage, short circuit & reverse polarity protection. 30-18kHz, Power: 4-14Vdc 150mA
E-1 Cebek Module £5.87
Proximity Card Reader Kit
A simple security kit with many applications. RFID technology activates a relay, either on/off or timed. Supplied with 2 cards, can be used with up to 25 cards. Power: 9Vac or dc
MK179 Velleman kit £14.25
Mini USB Interface Board
New from Velleman this little interface module with 15 inputs/outputs inc digital & analogue in, PWM outputs. USB Powered 50mA, Software supplied
VM167 Module £26.80
20W 2 Channel Amplifier
Mono amplifier with 2 channels (Low & High frequecy), 20W RMS 4Ω per channel, adjustable high level. 22-22kHz, short circuit & reverse polarity protection.
Power: 8-18Vdc 2A
E-14 Cebek Module £22.11
Running Microbug Kit
Powered by two subminiature motors, this robot will run towards any light source. Novel shape PCB with LED eyes.
Power: 2 x AAA Batteries
MK127 Velleman kit £9.02
Thermostat Mini Kit
General purpose low cost thermostat kit. +5 to +30°C Easily modified temperature range/min/max/hysteresis 3A Relay
Power: 12Vdc 100mA
MK138 Velleman Kit £4.55
5W Stereo Amplifier
Stereo power stage with 5W RMS 4Ω, 30-18kHz, short circuit & reverse polarity protection.
Power: 6-15Vdc 500mA
ES-2 Cebek Module £21.54
200W Power Amplifier
A high quality audio power amp, 200w music power @ 4Ω 3-200kHz Available as a kit without heatsink or module including heatsink.
K8060 Velleman kit £12.85
Heatsink for kit £9.95
VM100 Module £38.54
Velleman Function Generator
PC Based USB controlled function generator. 0.01Hz to 2Mhz Pre-defined & waveform editor. Software supplied. See web site for full feature list.
PCGU1000 Velleman £118.38
12Vdc Power Supply
Single rail regulated power supply complete with transformer. 130mA max, low ripple, 12Vdc with adjustment.
FE-103 Cebek Module £13.16
MP3 Player Kit
Plays MP3 files from an SD card, supports ID3 tag which can be displayed on optional LCD. Line & headphone output. Remote control add-on. Power: 12Vdc 100mA
K8095 Velleman kit £39.99
Velleman PC Scope
PC Based USB controlled 2 channel 60Mhz oscilloscope with spectrum analyser & Transient recorder. 2 Scope probes & software included. See web site for full feature list.
PCSU1000 Velleman £249.00
1-180 Second Timer
Universal timer with relay output. Time start upon power up or push button. LED indication. 5A Relay
Power: 12Vdc 60mA
I-1 Cebek Module £12.92
DC to Pulse width Modulator
A handy kit to accurately control DC motors etc. Overload & short circuit protection. Input voltage 2.5-35Vdc, Max output 6.5A.
Power: 8-35Vdc
K8004 Velleman kit £9.95
Velleman PC Scope/Generator
PC Based USB controlled 2 channel oscilloscope AND Function generator. Software included. See web site for full feature list.
PCSGU250 Velleman £113.67
Cyclic Timer
Universal timer with relay output. Time start upon power up or push button. On & Off times 0.3-60 Seconds, LED indication. 5A Relay
Power: 12Vdc 80mA
I-10 Cebek Module £14.12
Audio Analyser Kit
A small spectrum analyser with LCD. Suitable for use on 2, 4 or 8Ω systems. 300mW to 1200W(2Ω) 20-20kHz Panel mounting, back-lit display. Power: 12Vdc 75mA
K8098 Velleman kit £31.65
RF Remote Control Transmitter
Single channel RF keyfob transmitter with over 13,122 combinations. Certified radio frequency 433.92MHz.
Power: 12Vdc 2mA (inc) For use with TL-1,2,3,4 receivers.
TL-5 Cebek Module £14.64
Light Detector
Adjustable light sensor operating a relay. Remote sensor & terminals for remote adjustment pot. 5A Relay
Power: 12Vdc 60mA
I-4 Cebek Module £13.98
USB
USB DMX Interface
512 DMX Channels controlled by PC via USB. Software & case included. Available as a kit or ready assembled module.
K8062 Velleman kit £47.90
VM116 Module £67.15
RF Remote Control Receiver
Single channel RF receiver with relay output. Auto or manual code setup. Momentary output, 3A relay
Power: 12Vdc 60mA For use with TL-5 or TL-6 transmitters.
TL-1 Cebek Module £28.25
Liquid Level Detector
A liquid level operated relay. Remote sensor operates relay when in contact with a liquid. 5A Relay
Power: 12Vdc 60mA
I-6 Cebek Module £13.08
USB Interface Board
Featuring 5 in, 8 digital outputs, 2 in & 2 analogue outputs. Supplied with software. Available as a kit or ready assembled module.
USB
K8055 Velleman kit £24.80
VM110 Module £34.90
Keypad Access Control
An electronic lock with up to ten 4 digit codes. Momentary or timed (1-60ec/1-60min) output. Relay 5A
Power: 12Vdc 100mA Keypad included.
DA-03 Cebek Module £54.26
Thermostat
A temerature controlled relay. Adjustable between -10 to 60°C Sensor on remote PCB. Connector for external adjustment pot. 5A Relay
Power: 12Vdc 60mA
I-8 Cebek Module £12.80
8 Channel USB Relay Board
PC Controlled 16A relays with toggle, momentary or timed action. Test buttons included, available in a kit or assembled.
K8090 Velleman kit £39.95
VM8090 Module £58.40
AC Motor Controller
A 230Vac 375W motor speed control unit giving 33 to 98% of full power.
Power: 230Vac
R-8 Cebek Module £12.14
Start / Stop Relay
Simple push button control of a relay. Either 1 or 2 button operation 5A Relay
Power: 12Vdc 60mA
I-9 Cebek Module £12.83
Components
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Transformers
Motors
PCB Equipment
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How safe are your digits?

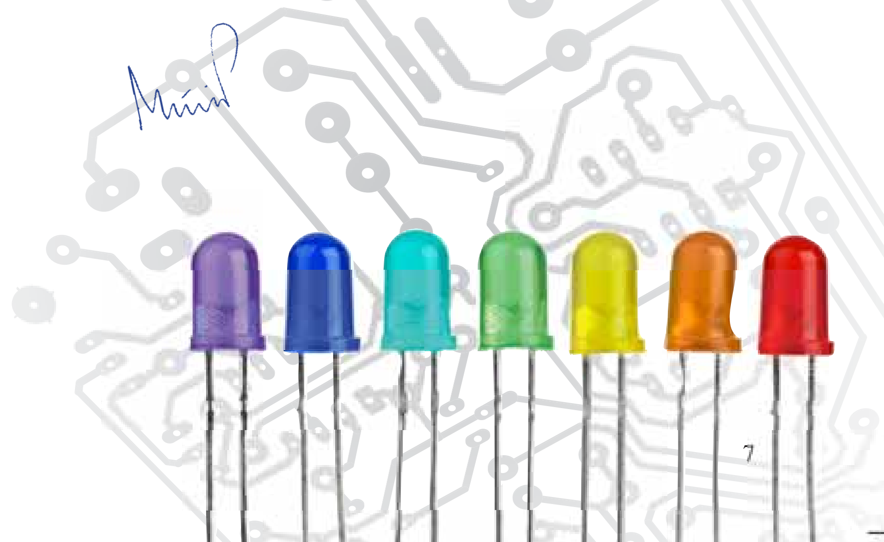
I'm sure your fingers are fine, but what about all your ones and zeroes? Although it is still perfectly possible to live without a computer, the Internet, email and a mobile/smart phone, most of us are more than happy to take advantage of the work, social and entertainment opportunities provided by the digital revolution.

These systems (usually) work so effortlessly that it is easy to believe that they are purely benign and only do what we what them to do. However, the increasing number of leaks, hacks and other revelations about the vulnerabilities of digital systems should make all of us keep an eye on what we store and where we store it.

This is about to become all the more important, as 'cloud-based' systems become increasingly prevalent. The main idea with 'clouds' is that you store files on a distant rack of hard drives, and access them as and when you need to from your home or work PC, or increasingly your smartphone. In some ways it's a great idea – you only need one version of a file and you can be sure that your files are backed up effectively. On the other hand, how do you know files are secure? This is still a very new technology, and it's well worth checking that your digital life is properly encrypted and safe from unauthorised access.

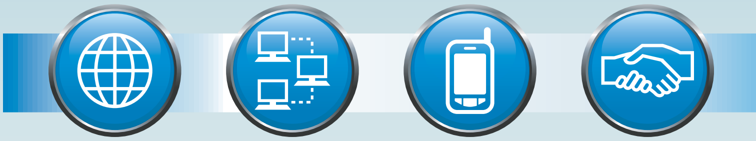
Apart from security, there is also the question of reliable access – your files will only be available when you have a working Internet connection. I don't know about your ISP, but mine is really only good enough for about 50 weeks a year. On the face of it, not a bad score, but that still leaves one or two weeks – spread out over a year – when Internet access ranges from poor to abysmal, to non-existent.

I couldn't do my job without email, so I now have a reasonably good 'insurance' system by 'tethering' my smartphone to a laptop. It's not the fastest link, but keeps me going if my cable connection is down because a road digger cuts me off, or the ISP has decided that is needs to 'carry out essential maintenance' and leaves me disconnected for six hours. However, the thought of not only being without email, but also temporarily losing my work files, music, photographs and all the other digital bits and pieces in my computer leaves me cold, and I certainly wouldn't want to access that lot via my smartphone. It may well be that clouds are the way of the future, but I don't think I'll be an 'early adopter'. In the meantime, I do remember – as should you – the old adage: there are only two kinds of hard drives, ones that have failed, and ones that are going to fail. So, wherever your files live, back-up back-up, and back-up again!



NEWS

A roundup of the latest Everyday News from the world of electronics



Will UltraViolet rain on iCloud's parade? by Barry Fox

Apple grabbed advantage of the record industry's failure to agree a unified strategy on online music download sales, and made iTunes the *de facto* standard. Apple is now hoping to repeat history with online streaming of music, movies, TV shows and electronic books from an iCloud 'digital locker', to subscribers with up to ten iPods, iPads or iPhones. This puts Apple in direct competition with DECE, the Digital Entertainment Content Ecosystem, which promotes the gestating UltraViolet digital locker cloud system.

DECE has been planning and promising a digital locker system since 2008 and has – at least tentative – support of most major hardware and software companies, with the notable exception of Apple. Hard facts on UltraViolet only began to emerge at the *Consumer Electronics Show* in Las Vegas, last January, and the organisation has since been largely silent on progress.

However, by happy coincidence, Tim Wright, VP worldwide, new media and technology, Sony Pictures, and DECE spokesman, had already been scheduled to give a routine progress report on UltraViolet at *Insight 360°*, an entertainment industry forum held in London by the Industry Trust for IP Awareness, British Video Association (BVA), Motion Picture Association (MPA) and British Film Institute (BFI) – on a day which turned out to be the day after Apple's surprise announcements.

'Why should dealers and consumers be tied in to a proprietary system, when there is an open system with a wide range of devices?' Wright asked the audience rhetorically. 'We are offering openness and diversity and consistency for the user. Freedom of entitlement is coming in 2011. UltraViolet is an open and shared system, not the closed approach that others have announced.'

But hard facts on UltraViolet's commercial launch plans remained sparse. After screening the same, or very similar, promotional video shown at *CES* in January, Tim Wright reiterated that anyone with a free UV account will be able to use purchased 'UV' programming on up to 12 devices, with access by up to six household members, with up to three of them streaming simultaneously.

Can iCloud repeat the success of iTunes?

The launch timescale remains only broadly defined, with the US 'first in the fall', the UK and Canada sometime in late 2011 and 'other countries in 2012.'

'We are continuing to build' says Wright. Apps for Windows and Android devices are expected 'within 2011' and devices with embedded UltraViolet capability some time in 2012.

There is still no clear guidance on upgrading existing hardware. 'I suspect many devices can be made UV-compatible by software download' says Wright, without elaborating.

'We look forward to telling you more at future events'; he said as he finished his talk, without offering the audience an opportunity to ask questions.

Earlier, Chris Law, MD, Warner Bros Entertainment UK, had said: 'It will take 12 to 18 months until there is a robust mass market for digital sell through. UltraViolet is just about to launch in the US and is due in the UK at the end of the year.'

'There is a lot to be done. We want a seamless flexible proposition. It's what's needed for sell through to transition from DVD and Blu-ray. Apple has done a fantastic job with iTunes and there is a lot to be done to get digital sell through into non-Apple products'. The question remains, 'is this too little too late?', as Apple's iCloud appears on the horizon.

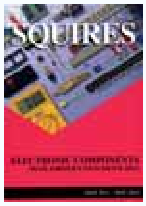
CHROME-PLATED COMPUTING

If you fancy a change of operating system from the dominant trio of Windows, OSX and Linux then there's good news. Google's Chrome OS has launched in the US with 'Chromebook' laptops from Samsung. The UK launch is slated for August.

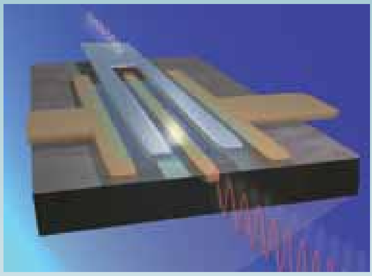
Squires catalogue

Component and tool vendor, Squires, has launched their new catalogue. It features a wide range of electronic components, including: batteries, cable, cases, connectors, motors, fuses, LEDs, resistors, semiconductors, transformers, test equipment and much more.

Readers who would like to receive a free copy can phone (01243 842424) or email (**sales@squirestools.com**) to request one. It can be viewed online at: **www.squirestools.com**.



World's fastest graphene transistor



IBM researchers have demonstrated a radio-frequency graphene transistor with the highest cut-off frequency achieved so far for any graphene device – 100GHz. This high frequency record was achieved using wafer-scale, epitaxially grown graphene using processing technology compatible to advanced silicon device fabrication.

This accomplishment is a key milestone in an effort to develop the next-generation of communication devices based on carbon. 'A key advantage of graphene lies in the very high speeds in which electrons propagate, which is essential for achieving high-speed, high-performance next generation transistors,' said Dr TC Chen, vice president, science and technology, IBM Research. 'The breakthrough we are announcing demonstrates clearly that graphene can produce high performance devices and integrated circuits.'

Graphene is a single atom-thick layer of carbon atoms bonded in a hexagonal honeycomb-like arrangement. This two-dimensional form of carbon has unique electrical, optical, mechanical and thermal properties and its technological applications are being explored intensely.

Uniform and high-quality graphene wafers were synthesised by thermal decomposition of a silicon carbide (SiC) substrate. The graphene transistor itself, used a metal top-gate architecture and a novel gate insulator stack involving a polymer and a high dielectric constant oxide. The gate length was modest, 240nm, leaving plenty of space for further optimisation of its performance by scaling down the gate length.

It is noteworthy that the frequency performance of the graphene device already exceeds the cut-off frequency of state-of-the-art silicon transistors of the same gate length (~40GHz). Similar performance was obtained from devices based on graphene obtained from natural graphite, proving that high performance can be obtained from graphene of different origins. Previously, the team had demonstrated graphene transistors with a cut-off frequency of 26GHz using graphene flakes extracted from natural graphite.

Free potentiometer lubricant – an exclusive EPE offer!

Potentiometers and sliding position sensors are electromechanical devices whose performance and operating life can be dramatically improved through lubrication. Each of these devices has a metal wiper that moves along a resistive element or track to regulate current flow to a device, or to indicate when pre-calibrated positions are reached. Lubricating these tracks helps to prevent wear, attenuate electrical noise and extend operating life.

Wear prevention is the primary reason for potentiometer track lubrication. Most importantly, the lubricant film must be strong enough to prevent wear, but thin enough throughout the operating range to prevent contact hydroplaning and resulting intermittencies. When working with small, delicate mechanisms with extremely low starting torque, oils may be required. However, greases, with their important 'stay-in-place' advantage, have been the most successful potentiometer lubricants. Light, low shear greases, some approaching a semi-fluid state, can often be designed for even very low power applications.

EPE *and* Newgate *are giving readers the opportunity to trial a specialist potentiometer/sliding position sensor lubricant for* ***free****. For details, see:* **www.potentiometerlubricant.co.uk**

Pico Technology's fastest ever PicoScope!

The new four-channel PicoScope 6404 PC oscilloscope has an analogue bandwidth of 500MHz. This is matched by a real-time sampling rate of 5GS/s, which guarantees accurate representation of signals up to the full bandwidth. The scope also has an ultra-deep 1GS (gigasample) buffer memory that allows capture and analysis of complex waveforms, even when sampling at full speed.

As well as the headline specifications, the scope offers a built-in function generator, arbitrary waveform generator, mask limit testing, switchable bandwidth limiting on each channel, and switchable 1MΩ and 50Ω inputs. This is in addition to the spectrum analysis, advanced triggering and serial decoding that are already standard features of Pico PC Oscilloscopes.

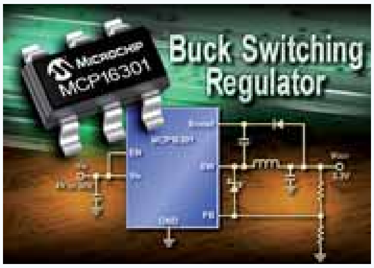
The scope connects to any Windows XP, Vista or Windows 7 PC with a USB 2.0 port. You can use one with a PC to save space on your workbench, or connect it to a laptop

Picotech's 6404 PC oscilloscope

to create a portable instrument that's perfect for field servicing and on-site demonstrations. The high sampling rate and bandwidth makes this scope ideal for analogue and digital circuit designers, test engineers and installers. If you want to write your own application to control the scope or use it as a digitiser, Pico provides a software development kit, including example code, free of charge.

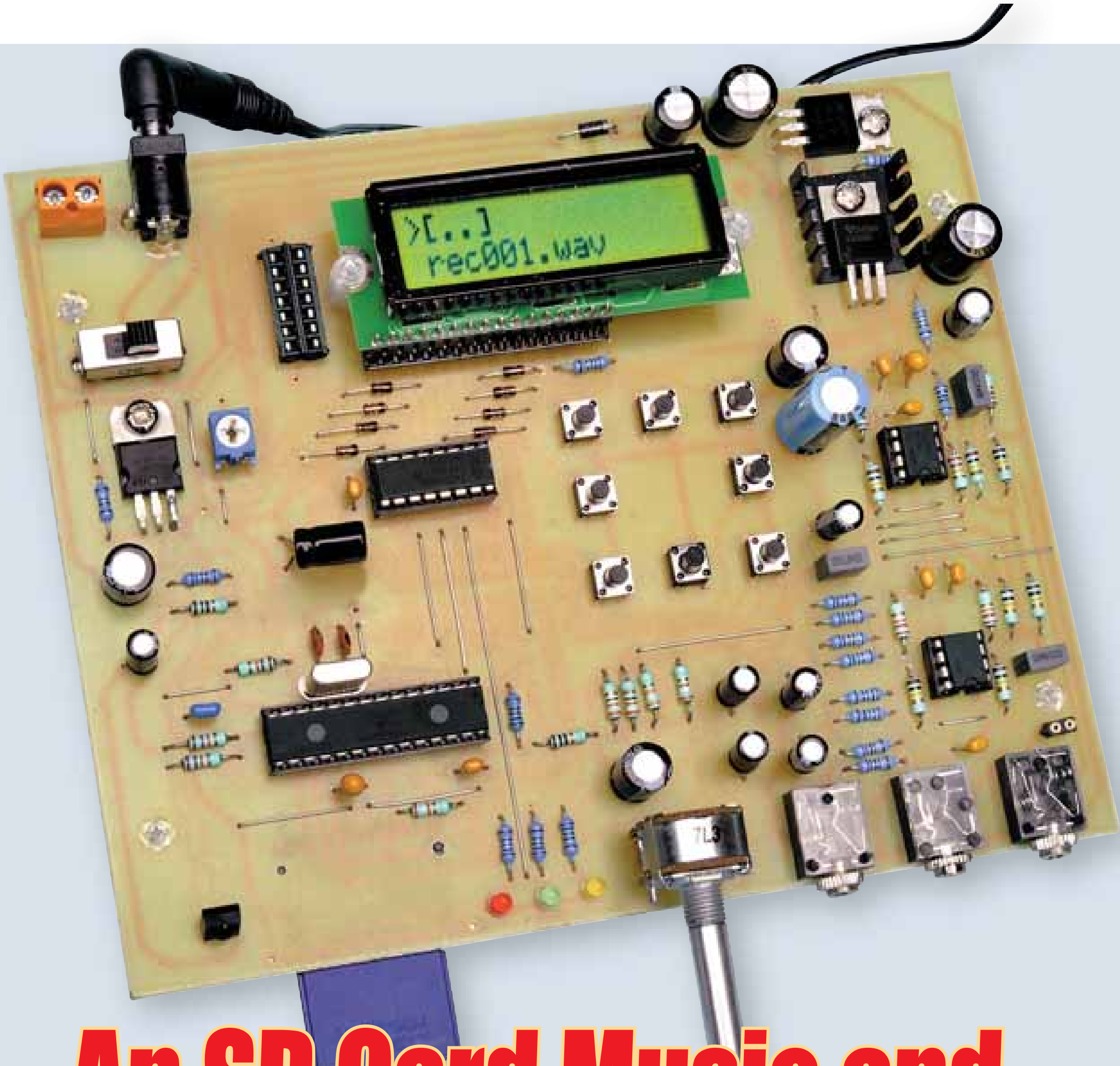
More information on Pico Technology can be found at **www.picotech.com**

A Microchip first



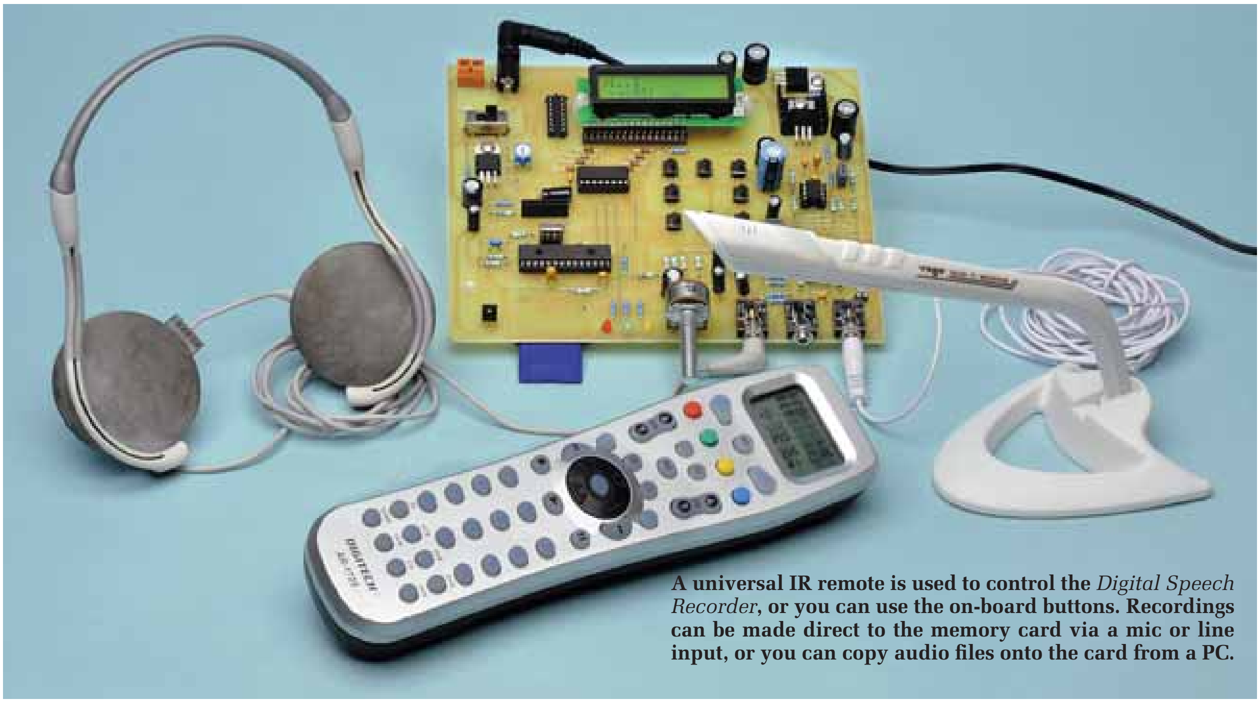
Microchip has announced its first 30V-input buck switching regulator. The MCP16301 combines a wide input voltage range of 4V to 30V, and a 600mA output across a voltage range of 2V to 15V, with up to 95% efficiency. The 'switch' integrated into the 6-pin package minimises the number of external components, enabling an efficient and compact solution for stepping down 12V to 24V DC power rails.

Low-cost ($15 to $20) demo boards and development resources for fast development are available. For more information visit the Microchip Web site at: **www.microchip.com/get/TQEG**



An SD Card Music and Speech Recorder/Player

This digital recorder stores WAV files on low-cost MMC/SD/SDHC cards. It can be used as a jukebox, a sound effects player or an expandable 'dictaphone'. You can use it as a free-standing recorder, or in conjunction with any Windows, Mac or Linux PC.



A universal IR remote is used to control the *Digital Speech Recorder*, or you can use the on-board buttons. Recordings can be made direct to the memory card via a mic or line input, or you can copy audio files onto the card from a PC.

IN the April 2011 issue of *EPE*, we published a very popular solid-state voice recorder project. The design was an improved version of older designs, employing the same voice recorder chip. These allowed you to record a number of short messages (up to about one minute of speech) and play them back at the touch of a button. The messages were stored in 'analogue EEPROM' cells in an analogue 8-bit format.

New level

This project takes the message recorder concept to a whole new level and employs a common SD memory card or MMC (multimedia card) for message storage. Depending on the size of the card, you can store and play back many hours of audio. We've also added infrared remote control and it can be used to play back any WAV file that you have downloaded or recorded on your PC.

The unit works with all commonly-available MMC, SD and SDHC memory cards. You can copy files from a PC onto these cards via an MMC/SD/SDHC card reader like the one shown at bottom right.

We are presenting this project in a very simple module format; it is just a PC board with an SD card socket, a 2-line LCD panel and eight pushbutton switches to select the audio files and other features. If you want to build the unit into a case, you can take the LCD panel off the board and separately mount it and the same goes for the switches and sockets.

Compatible memory cards

The compatible cards to use with this project are MMC (MultiMedia Card), SD (Secure Digital) and SDHC (Secure Digital High Capacity) cards. SD cards come in capacities up to 2GB. Beyond that, you will find SDHC cards with capacities from 4GB to 32GB. The current version of the standard does not specify cards with capacities higher than 32GB, although these will become common in the future.

This project will work with most presently available cards. SD-type cards in particular have dropped in price dramatically and you can now pick up a 4GB SDHD card for under a fiver – see **amazon.co.uk** for example.

In operation, the unit can be run from either a 12V battery or a DC plugpack supply. It can drive stereo

Parts List – Digital Audio Recorder/Player

1 PC board, code 815, available from the *EPE PCB Service*, size 164mm × 136mm
1 16 × 2 LCD module (DIL version, or SIL version) – see text
1 1kΩ horizontal-mount trimpot (VR1)
1 10kΩ log 16mm dual-gang pot (VR2)
8 SPST 6mm tactile switches (S1-S8)
1 DPDT PC-mount slide switch (S9) (Jaycar SS-0823)
1 2.5mm PC-mount male DC power connector (Jaycar PS-0520)
1 TO-220 mini heatsink (Jaycar HH-8502)
1 10MHz crystal (X1)
1 SD surface-mount card socket (Jaycar PS-0024) (CON1)
3 3.5mm PC-mount stereo jack sockets (Jaycar PS-0133)
1 infrared receiver module (IRD1) (Jaycar ZD-1952)
1 40-pin IC socket (to be cut)
1 28-pin IC socket (0.3-inch)
1 16-pin IC socket
2 8-pin IC sockets
12 M3 × 12mm nylon screws (some to be cut)
8 M3 × 9mm tapped nylon spacers
1 500mm 0.8mm-dia. length tinned copper (for links)
1 32-way machined pin socket strip
1 40-pin header strip
1 electret microphone insert (optional – see text)

Semiconductors
1 dsPIC33FJ64GP802-I/SP microcontroller (IC1) programmed for SIL version, or for DIL version – see text
1 74HC595 8-bit shift register (IC2)
2 LM833N dual op amps (IC3-IC4)
8 1N4148 signal diodes (D1-D8)
1 1N4004 silicon diode (D9)
1 7809 3-terminal regulator (REG1)
1 7805 3-terminal regulator (REG2)
1 LM317T variable regulator (REG3)
1 3mm red LED (LED1)
1 3mm green LED (LED2)
1 3mm yellow LED (LED3)

Capacitors
1 1000µF 16V electrolytic
2 470µF 25V electrolytic
3 470µF 16V electrolytic
1 220µF 16V electrolytic
5 100µF 16V electrolytic
3 10µF electrolytic
1 10µF tantalum
1 4.7µF electrolytic
2 220nF MKT polyester
2 150nF MKT polyester
3 100nF MKT polyester
5 100nF monolithic
2 18pF ceramic

Resistors (0.25W, 1%)

1 220kΩ	3 1kΩ
7 100kΩ	1 180Ω (R2)
5 39kΩ	1 110Ω (R1)
2 27kΩ	7 100Ω
5 22kΩ	3 10Ω
4 10kΩ	1 0Ω (R3)
2 2.2kΩ	

(Note: 10Ω and 160Ω resistors may be required to adjust REG3).

headphones or an external amplifier and loudspeakers.

WAV file format

The WAV file format from Microsoft can carry both compressed and uncompressed audio, but this speech recorder can *only* record and play back *uncompressed* WAV files. The samples are stored as 16-bit signed integers. The sampling rate of the encoded audio is stored in the WAV file header and is read by the recorder to vary the playback sampling speed.

Both stereo and mono files can be played. When playing mono files, both output channels (L and R) carry identical signals. A stereo WAV file contains information for the left and right channels interleaved, meaning every second sample is taken for each channel.

WAV files essentially store the PCM (pulse code modulation) samples of the audio waveform. The sampling frequency is twice the highest reproducible frequency in the audio stream. Note that WAV files have a '.wav' file extension.

Firmware overview

The firmware is responsible for all the features of the *Digital Speech Recorder*. When you play a file, the firmware reads the WAV header that stores the sampling rate of the audio file. It then sets up an interrupt to push data into the DACs (digital-to-analogue converters) in the microprocessor at the requested sampling rate from the memory card.

When recording, data from the micro's ADC (analogue-to-digital converter) is written to a WAV file on the memory card using double buffering. The audio buffer stores up to 10KB of audio samples, and each sample is 16 bits.

FAT files

In this case, FAT does not stand for fat or obese. Instead, it stands for 'File Allocation Table' and is a file management system that's commonly used for hard disk drives and memory cards.

This Digital Speech Recorder recognises the FAT/FAT32 file system, meaning you should be able to read the cards using any Windows, Mac or Linux box coupled to a card reader or by using a laptop PC with an inbuilt card reader.

If you want more information on the FAT file system, refer to **http://en.wikipedia.org/wiki/File_Allocation_Table** or to a myriad of other internet sites.

If your memory card has a different file system on it, you will need to format the memory card first using a FAT/FAT32 system. Be sure to back up whatever was on the card *before* you do this, because the formatting process will erase anything that is on the card.

File sizes

Because this project does not decode compressed audio files, the size of the WAV files used is rather large compared to common MP3 files or similar audio formats. A WAV file can be up to 10 times larger than an equivalent MP3 file at the 44.1kHz sampling rate. Unlike MP3, uncompressed WAV is a lossless encoding format. Using lower sampling rates can reduce file sizes, but this will also reduce the audio quality and bandwidth.

Because we are using cheap and readily available SD or MMC cards, we are not too concerned about the size of

Using Audacity To Convert MP3 Files To WAV Files

CONVERTING MP3 files (and other compressed audio formats) to WAV files suitable for the Speech Recorder is easy using a program called 'Audacity'. This freeware program allows you to convert at different sampling rates and can also be used as a basic sound editor.

Audacity can be downloaded from **http://audacity.sourceforge.net/download/**. There are versions for Windows, Mac and Linux. Follow the on-screen prompts after executing the downloaded installation program.

As indicated, Audacity can open MP3 (and other compressed) files. You can then export them to WAV format and copy them to an MMC/SD/SDHC card for use with this unit.

The first step in the conversion is to select the required sampling rate. This is a compromise between audio quality and the size of the file. The higher the sampling rate selected, the higher the audio quality but the bigger the file size.

Having selected the sampling rate, it's then just a matter of clicking 'File' and then selecting the 'Export As WAV...' option.

There is no reason to choose a sampling rate higher than 44.1kHz, as this is high enough to encompass the whole of the audio spectrum (remember that the sampling rate will be double the highest reproducible frequency and that the audio spectrum reaches up to about 22kHz). Having converted the files to WAV files, it's then just a matter of copying them from the PC to the memory card via a card reader.

the files. Even at 40MB per 4-minute audio track, you can still store around 100 songs (or 400 minutes) of audio on a £5 4GB SDHD card.

Circuit description

Refer now to Fig.1 for the full circuit details of the Digital Speech Recorder. As shown, it's based around a powerful 16-bit DSP microcontroller from Microchip, the dsPIC33-FJ64GP802 (IC1).

The reasons for choosing this microcontroller are fourfold. First, it is one of the first microcontrollers from Microchip to have an integrated stereo DAC. Second, it is very fast, running at 40MIPS (millions of instructions per second). You need such speed when you are reading from a memory card in real time and dumping audio data onto the DACs.

Third, it has enough on-board RAM and program memory to implement the features of this project, and it comes in a through-hole package which is easier to install than an SMD. And finally, it runs from a 3.3V supply, which is compatible with the supply requirements for a typical memory card.

IC1's system clock is derived from a 10MHz crystal (X1) via a PLL (phase-locked loop) stage to derive a 40MHz instruction clock. The two accompanying 18pF ceramic capacitors provide the correct loading for the crystal.

In operation, the microcontroller is responsible for implementing the hardware layer to read and write sectors to the MMC/SD/SDHC card. This low-level layer is called by higher layers that implement a FAT/FAT32 file system. The result is that we can read and write files.

The SPI (serial peripheral interface) outputs of the microcontroller connect to the SD card and to IC2, a 74HC595 8-bit shift register that's used to drive the LCD module. This shift register is used as a 'port expander' because there are simply not enough output pins on the microcontroller.

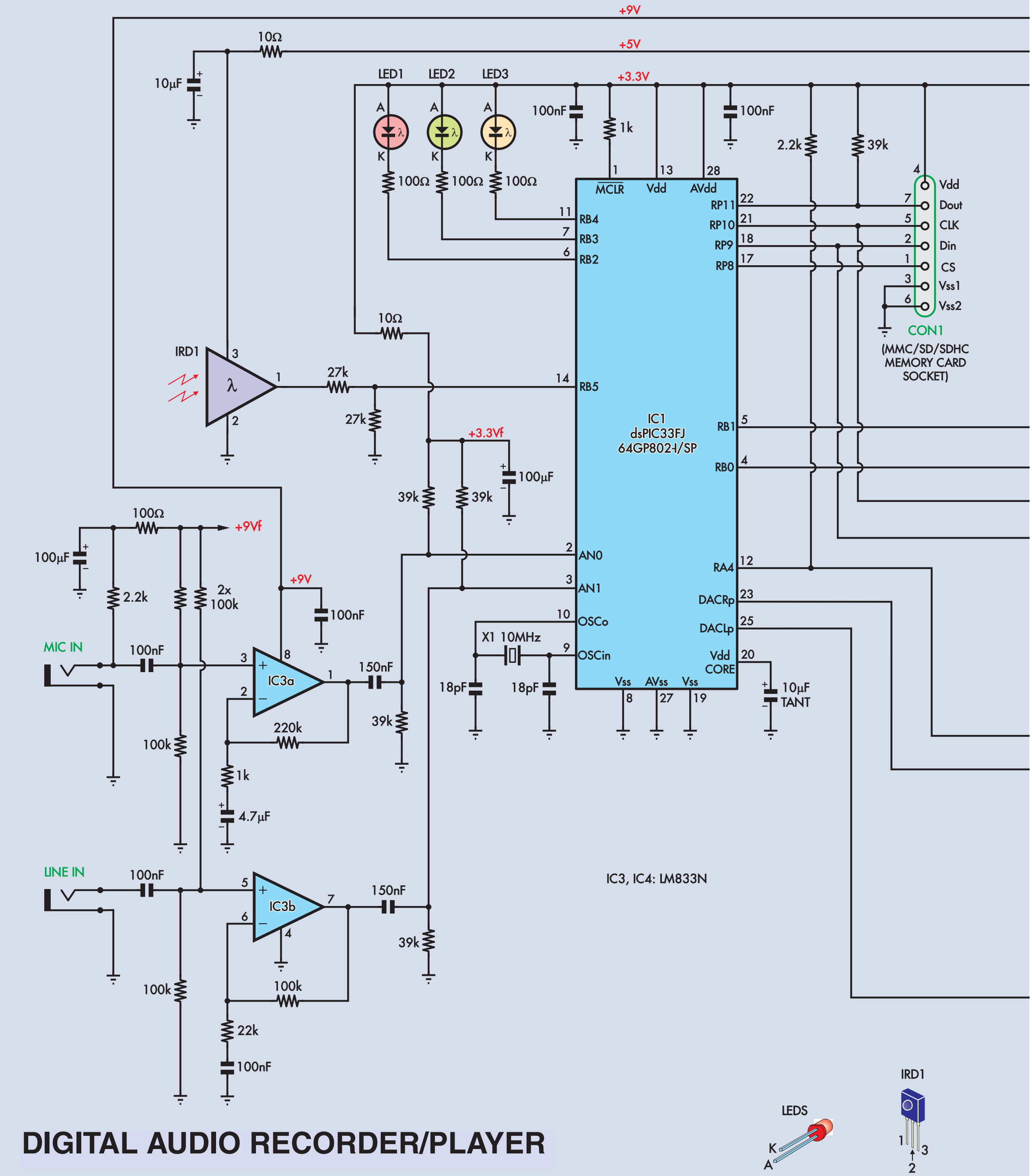
The output of the shift register is also used to scan the eight on-board tactile switches, S1 to S8. These are connected via diodes D1 to D8, which effectively form a wired AND gate and they are active low. The microcontroller can detect a switch press by loading the shift register with the values 0xFE, 0xFD, 0xFB, 0xF7 and so on, up to 0x7F (one 0 bit).

Note that the E (enable) line to the LCD module is kept low during this scan, so as not to affect the contents of the display.

Remote control

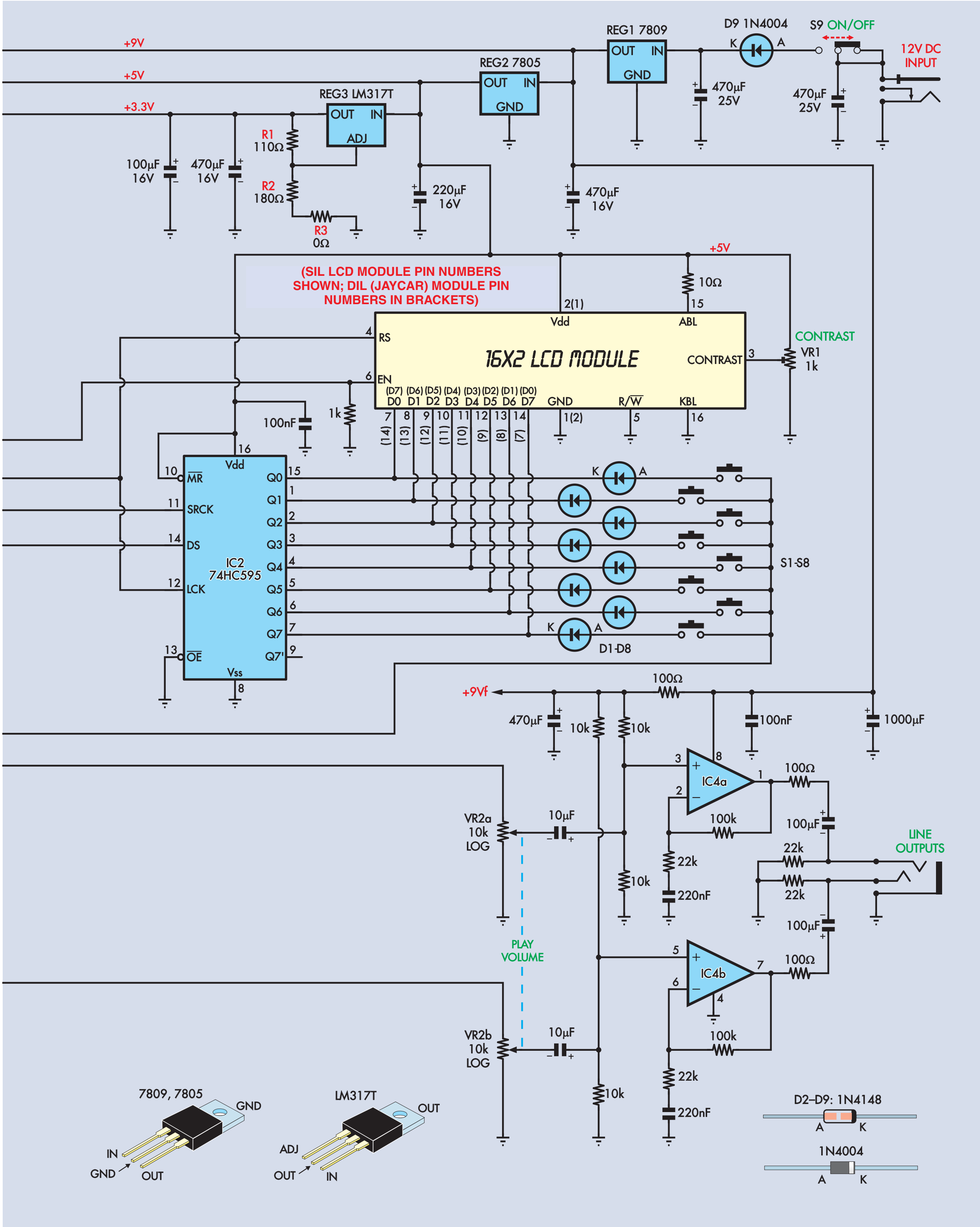
The speech recorder and audio player can also be operated using a remote control. The infrared signals are amplified, filtered and demodulated by an infrared module (IRD1). Its supply is decoupled using a 10Ω resistor and 10µF electrolytic capacitor. The data line passes through a voltage divider consisting of two 27kΩ resistors to pin 14 (RB5) of IC1.

Note that the infrared module works from a +5V rail, whereas the microcontroller decoding the signal runs from a 3.3V rail. The purpose of the voltage



DIGITAL AUDIO RECORDER/PLAYER

Fig.1: the circuit is based on a dsPIC33-FJ64GP802 microcontroller and a 16 × 2 LCD module. The micro scans the switch inputs via shift register IC2, drives the memory card, decodes the signals from the infrared receiver module (IRD1), writes to the LCD module and performs the ADC conversions on the analogue inputs.



+9V
+5V
+3.3V
REG1 7809
REG2 7805
REG3 LM317T
OUT IN GND ADJ
D9 1N4004
S9 ON/OFF
12V DC INPUT
470µF 25V
R1 110Ω
R2 180Ω
R3 0Ω
100µF 16V
470µF 16V
220µF 16V
(SIL LCD MODULE PIN NUMBERS SHOWN; DIL (JAYCAR) MODULE PIN NUMBERS IN BRACKETS)
16X2 LCD MODULE
Vdd ABL RS EN CONTRAST GND R/W KBL
(D7) (D6) (D5) (D4) (D3) (D2) (D1) (D0)
D0 D1 D2 D3 D4 D5 D6 D7
CONTRAST VR1 1k
10Ω
100nF
1k
IC2 74HC595
Vdd MR SRCK DS LCK OE Vss Q0 Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q7'
S1-S8
D1-D8
+9Vf
100Ω
470µF
10k
100nF
1000µF
IC4a
IC4b
100k
22k
220nF
10µF
VR2a 10k LOG
VR2b 10k LOG
PLAY VOLUME
LINE OUTPUTS
100µF
7809, 7805
IN GND OUT
LM317T
ADJ OUT IN
D2–D9: 1N4148
1N4004
A K

Main features and specifications

- Uses an MMC/SD/SDHC card to store audio files
- Stores mono recordings as Microsoft WAV files at 16kHz sampling rate
- Plays back Microsoft WAV files at up to 44.1kHz sampling rate
- Uses FAT/FAT32 file system (transfer files to any PC operating system)
- Has mono microphone and line inputs for recording
- Stereo socket for line output or headphone use
- 2-line LCD to display file names, show volume and other settings
- Can be controlled using on-board switches or any RC5 universal remote control
- Unit can learn remote control codes
- Signal-to-noise ratio: –70dB unweighted (22Hz to 22kHz) with respect to 1.6V RMS
- THD+N: 0.7% at 1kHz

divider is to roughly halve the signal level from the module so that it can be used with a 3.3V device.

SPI mode

As noted above, the SPI peripheral on the microcontroller is used to drive the LCD and scan the tactile switches. However, it's also used to read from and write to the MMC/SD/SDHC card.

This means that we are using the MMC/SD/SDHC card in SPI mode (MMC/SD/SDHC cards can be used in either native mode or in SPI mode). The advantage of SPI mode is that any off-the-shelf microcontroller that has an SPI peripheral can be used, making the hardware layer easy to implement.

The interface with SPI may be simple, but the penalty is slower transfer speeds. However, SPI speeds are adequate for real-time playing (and recording) of audio. SPI also requires less interface pins and they are at a premium, as you can see.

Analogue stages

The outputs of the two internal DACs are fed via dual-gang potentiometer VR2 to an LM833N low-noise dual op amp (IC4a and IC4b). Both op amp stages are wired as AC-coupled non-inverting amplifiers with a gain of 5.5. The 220nF capacitor to ground from each feedback divider network rolls off the DC gain and sets the low-frequency response.

The outputs at pins 1 and 7 are each fed to the line output socket via a 100Ω resistor and a 100µF capacitor, and can either drive stereo headphones or the line inputs of a stereo amplifier. Note that the LM833 is not really intended for driving low impedance loads, but it is a low-cost solution for a headphone output.

On-board control button functions

If you don't wish to use a remote control with this project, you can use the on-board buttons to control it. Their functions are as follows:

Functions while not playing or recording:

S1: Random shuffle
S2: Up
S3: Record mic
S4: Delete a file
S5: Record line in
S6: Down
S7: N/A
S8: Play

Functions while playing or recording:

S1: Volume up
S2: N/A
S3: Choose display up
S4: Stop
S5: Choose display down
S6: N/A
S7: Volume down
S8: Pause

There are two analogue input channels, the microphone input and the line input, and they are provided by another LM833N low-noise dual op amp (IC3). IC3a is the microphone preamplifier. It is a non-inverting stage with a gain of 221 (+46dB), as set by the 220kΩ and 1kΩ feedback resistors connected to pin 2. The 4.7µF capacitor sets the low-frequency rolloff.

The microphone itself can be an on-board electret microphone insert or you can use a PC microphone (eg, Jaycar AM-4087) plugged into the 3.5mm stereo input jack – see photo. A 2.2kΩ resistor provides the biasing current for the electret microphone and its DC supply is decoupled from the +9Vf supply using a 100Ω resistor and 100µF electrolytic capacitor.

IC3b is the line input preamplifier. It has a gain of 5.5 (+14.9dB), as set by the 100kΩ and 22kΩ feedback resistors connected to pin 6.

The outputs of both preamplifier stages are fed to the ADC inputs (AN0 and AN1) of IC1 via 150nF capacitors. Each ADC input is biased to half the +3.3V rail via voltage dividers, each consisting of two 39kΩ resistors.

Power supply

The circuit can be powered from either a 12V battery or a 12V DC plugpack supply. In operation, the 12V DC supply is fed in via on-off switch S9 and reverse polarity protection diode D9. Note that a 470µF 25V electrolytic capacitor is connected adjacent to the DC input socket, and is not protected from reverse polarity by D9 (this reduced the hum the most).

There are three 3-terminal regulators to provide the required supply rails. First, a 7809 9V regulator (REG1) provides the 9V rail for the analogue stages. It has 470µF and 1000µF capacitors across its output at different positions on the PC board. Further decoupling is provided by a 100Ω resistor and 470µF capacitor to provide the +9Vf rail, which provides the biasing for the op amp stages.

The main +9V rail is also fed to REG2, a 7805 regulator, to derive the +5V rail. This is used to power the LCD module, shift register IC2 and the infrared receiver module (IRD1).

This +5V rail also feeds REG3, an LM317T adjustable voltage regulator. This produces the +3.3V rail that's

MMC, SD and SDHC Memory Cards

Both MMC (MultiMedia Card) and SD (Secure Digital) cards are a type of non-volatile storage that uses FLASH memory technology. Similarly, SDHC (HC = high capacity) cards are a type of SD card with capacities between 4GB and 32GB.

All three types of cards can be used with this project. While they all look alike, MMC cards have only seven contacts, whereas SD cards have nine.

Note that miniSD and microSD cards can also be used as these are essentially SD cards with a smaller form factor. You will, however, need an external adaptor to convert them to standard size to connect to the Digital Speech Recorder.

MMC/SD/SDHC cards are commonly used in portable devices like mobile phones, computers, cameras and audio players, among others. They conveniently store a lot of data in a small form factor, consume little power and are light. Cards with increasingly larger storage capacity have been steadily appearing since their introduction in the late 1990s.

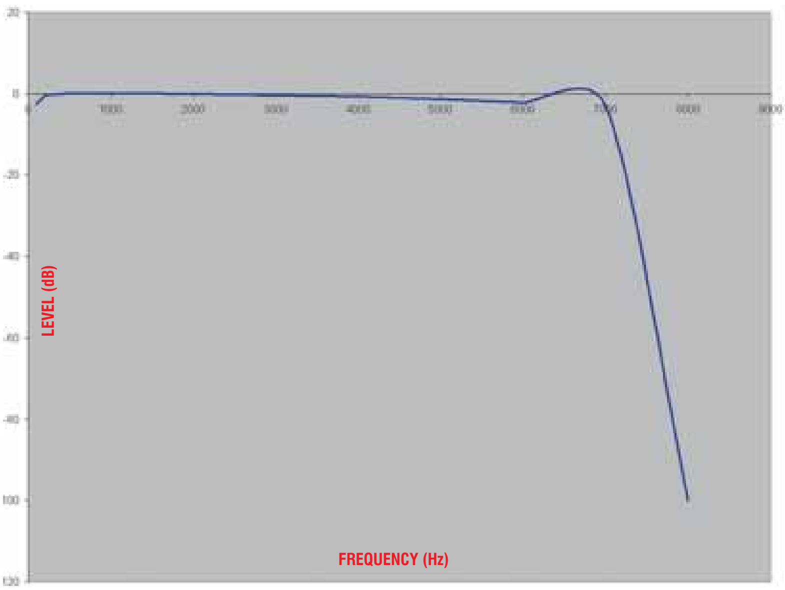


Fig.2: this graph shows the frequency response for recordings made on the Digital Speech Recorder. Note that the response is limited to half the sampling frequency, which is fixed at 16kHz for recording. The frequency response can be much wider for files recorded on a PC and transferred to the memory card.

used by the microcontroller and MMC/SD/SDHC card.

The accuracy of the +3.3V rail is important, because some MMC/SD/SDHC cards operate over quite a narrow voltage range. The firmware checks that the inserted card operates at 3.3V; so it is *crucial* that the supply rail be quite close to +3.3V.

The output voltage of REG3 is set by the divider network between its output terminal and its ADJ terminal to ground. The output is set at:

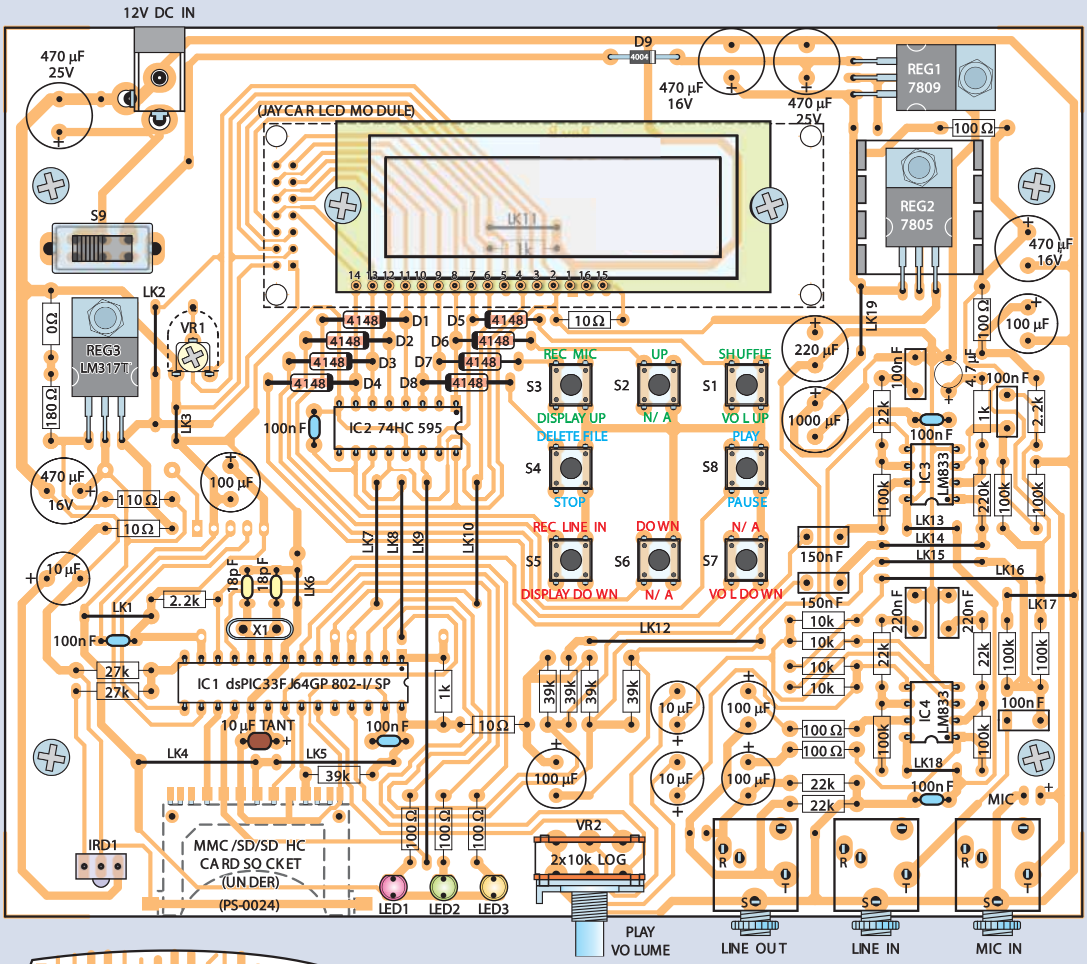
$$V_{OUT} = 1.25V \times (1 + (R2/R1))$$

With R2 = 180Ω and R1 = 110Ω, we get a supply of 3.29V (close enough to 3.3V). However, the 1.25V reference in the regulator can vary between 1.2V and 1.3V.

For this reason, provision is made on the PC board for an additional resistor (R3) to allow you to adjust the 3.3V supply rail if necessary. We will touch on this point later in the setting-up procedure.

Software

According to which LCD module you use you will need to select the



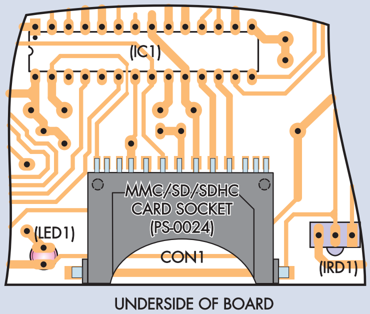


Fig.3 (above): install the parts on the PC board as shown on this component layout diagram. Take care to ensure that all polarised parts are correctly oriented and leave the ICs and the LCD module off the board until after the initial power supply checks have been completed.

Fig.4 (left): the memory card socket (CON1) is a surface-mount device (SMD) and is installed on the underside of the PC board as shown here. Lightly solder tack one pin first, then check the socket's alignment before soldering the remaining pins.

correct code for a dual in-line (DIL) or single in-line (SIL) version of the 16-character 2-line LCD. See **www.epemag.com** for software.

Construction

All components are mounted on a single-sided PC board, coded 815, measuring 164mm × 136mm This board is available from the *EPE PCB Service*. Fig.3 shows the parts layout on the board.

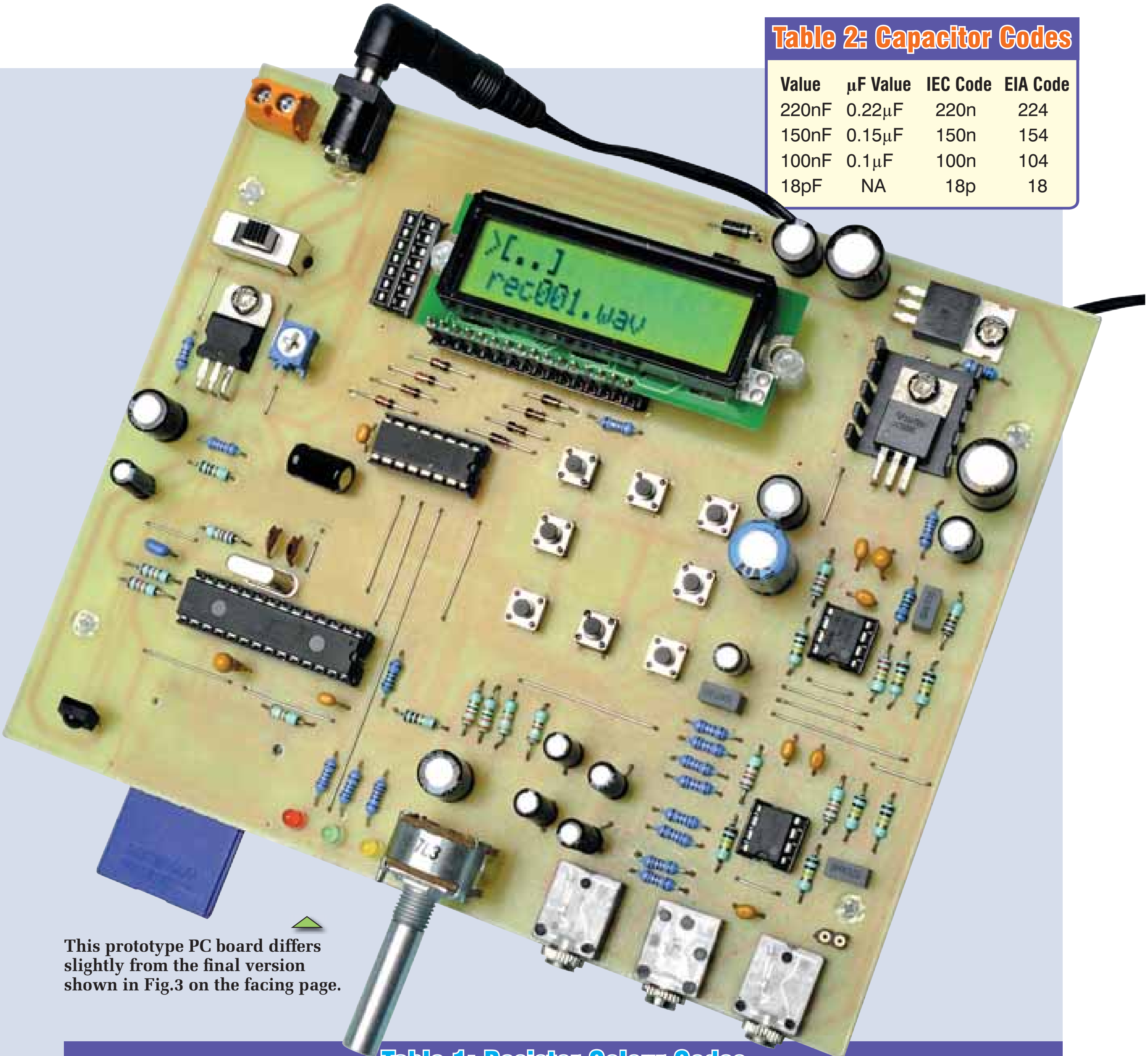
The first thing to do is to carefully inspect the board for hairline cracks and for shorts between adjacent copper tracks. It's rare that you will find a fault, but it's easier to spot any problems at this stage than after the parts have been installed.

Begin the assembly by soldering in the 18 wire links. You can straighten the link wire by clamping one end in a vice and then pulling on the other end with a pair of pliers to stretch it slightly. Don't forget link LK11 under the LCD module.

The resistors are next on the list, and again, one of these is under the LCD module. Table 1 shows the resistor colour codes, but you should also check each resistor using a DMM before

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
220nF	0.22µF	220n	224
150nF	0.15µF	150n	154
100nF	0.1µF	100n	104
18pF	NA	18p	18



This prototype PC board differs slightly from the final version shown in Fig.3 on the facing page.

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	220kΩ	red red yellow brown	red red black orange brown
❏	7	100kΩ	brown black yellow brown	brown black black orange brown
❏	5	39kΩ	orange white orange brown	orange white black red brown
❏	2	27kΩ	red violet orange brown	red violet black red brown
❏	5	22kΩ	red red orange brown	red red black red brown
❏	4	10kΩ	brown black orange brown	brown black black red brown
❏	2	2.2kΩ	red red red brown	red red black brown brown
❏	3	1kΩ	brown black red brown	brown black black brown brown
❏	1	180Ω	brown grey brown brown	brown grey black black brown
❏	1	110Ω	brown brown brown brown	brown brown black black brown
❏	7	100Ω	brown black brown brown	brown black black black brown
❏	1	0Ω	black	black

Transferring files and recording to the memory card

To transfer audio files from a PC to the memory card, you will need a low-cost SD/SDHC/MMC-card reader. The one shown in the accompanying photo is available from Jaycar for a few pounds (Cat No: XC-4756).

Note that before copying the files (eg, music tracks) to the MMC/SD/SDHC card, they must first be converted to WAV format. This can be done using a freeware sound editor program called 'Audacity' – see panel on page 13.

As indicated earlier, you can also directly record files to a memory card in the Digital Audio Recorder. Basically, you have two choices when making recordings: either use the microphone input or feed signals in via the recorder's line input.

When using the microphone input, you can use either an onboard electret microphone (see photo), or you can plug an electret microphone into the MIC In socket. Be sure to disconnect the on-board microphone if you are using an external one.

Note that the microphone and line inputs differ in the gain of their respective preamplifier stages, so be sure also to choose the correct input.

soldering it to the board. Resistor R3 can be either a 0Ω resistor or you can simply install a wire link **(note: this 0Ω resistor may have to be changed later – see section on trimming the 3.3V rail).**

Follow these parts with the diodes and the infrared receiver (IRD1). Note that D9 is a 1N4004 type, while the remaining eight diodes (D1-D8) are all 1N4148 signal types. These diodes must all be installed with the correct orientation (the striped end is the cathode (K)), while IRD1 must go in with its domed lens facing outwards.

The three LEDs (LED1 to LED3) can be installed at this stage as well. Make sure that these are oriented correctly and match the colours shown on Fig.3.

Installing the regulators

The three TO-220 regulators (REG1 to REG3) can now go in. As shown, these are all mounted horizontally, with their leads bent down at right-angles about 6mm from their bodies. In addition, the 7805 regulator (REG2) must be fitted with a mini finned heatsink

This larger-than-life size view shows how the card reader is mounted on the copper side of the PC board.

before it is bolted down. Each regulator is secured using an M3 × 5mm machine screw and nut.

The next step is to install the four IC sockets. If you don't have a 28-pin 0.3-inch socket (or have a 0.6-inch socket instead), you can cut it down the middle and install the two strips for IC1. Place each socket so that its notch matches that shown on the overlay (Fig.3). This will make it easier when it comes to installing the ICs later on.

You will also need to cut down a 40-pin IC socket to make the connector for the LCD module. If you are using the DIL (Jaycar QP-5515) module, you will need two rows of seven pins and they must be installed with what were originally their outside edges touching in the middle, otherwise they won't fit in place.

Now move on to the capacitors. There are four different types: monolithic, ceramic, MKT and electrolytic. The first three types can go in either way around, but the electrolytic capacitors are polarised and each must be oriented as shown in Fig.3. The negative terminal is marked on the body of each capacitor.

The switches can go in next. The power switch (S9) is a DPDT slide type, while the rest (S1 to S8) are momentary pushbutton tactile types. Note that these tactile switches are not symmetrical in the horizontal and vertical directions, being slightly longer in the vertical direction.

It's just a matter of installing them with their terminals positioned as shown (they won't fit the wrong way).

Defining the remote control codes

If you wish to use a remote control with this unit, you will need an RC5-compatible remote. RC5 is an infrared communications protocol that was initially developed by Philips and is used by many Philips appliances.

This means that if you have a universal remote, there's a good chance it will work if you set it to control a Philips appliance. For example, we tested the project with the Jaycar AR-1726 remote and can confirm that it works.

Setting up the remote is straightforward. You start by pressing the S2 and S6 (UP and DOWN) buttons together while booting the recorder, to enter the remote control programming menu. You are then prompted to press the key you want to define for that function.

For example, you may be prompted to 'Press Play' and you then simply press the relevant button on the remote which is to be assigned that function.

A recommended set-up using the AR-1726 Remote from Jaycar is shown in Table 3. It should be set to the VCR 917 code, which corresponds to the default programmed into the recorder's firmware.

Table 3: Recommended key assignments for Digitech AR-1726 remote control		
Button	Function(s)	Recommended Key Definitions for the Digitech AR-1726 Remote
0	Unused	Press '0'
1	In Triggered mode, used to play file rec001.wav	Press '1'
2	In Triggered mode, used to play file rec002.wav	Press '2'
3	In Triggered mode, used to play file rec003.wav	Press '3'
4	In Triggered mode, used to play file rec004.wav	Press '4'
5	In Triggered mode, used to play file rec005.wav	Press '5'
6	In Triggered mode, used to play file rec006.wav	Press '6'
7	In Triggered mode, used to play file rec007.wav	Press '7'
8	In Triggered mode, used to play file rec008.wav	Press '8'
9	In Triggered mode, used to play file rec009.wav	Press '9'
VOL UP	In Normal mode, used to select a file to play. While playing, used to increase the volume	Press 'Vol Up'
VOL DOWN	In Normal mode, used to select a file to play. While playing, used to decrease the volume	Press 'Vol Down'
CH UP	While playing, used to select what is displayed in the second line on the LCD module	Press 'Ch Up'
CH DOWN	While playing, used to select what is displayed in the second line on the LCD module	Press 'Ch Down'
MENU	Used to delete the selected file; confirmation is requested	Press 'Menu'
STOP	Used to stop a playing file or a recording	Press 'Stop'
PLAY	Used to play the selected file	Press 'Play'
PAUSE	Used to pause a playing file or a recording	Press 'Pause'
FAST FWD	Used to start random shuffle	Press 'FF'
REWIND	Unused	Press 'Rewind'
RECORD	Used to initiate a recording from the microphone input	Press 'Rec'
OK	Unused	Press 'Ok'
EXIT	Unused	Press 'Exit'
LINE	Used to initiate a recording from the line input	Press '->'

The larger items can now be installed. These include trimpot VR1, dual-gang potentiometer VR2, the DC connector and the three 3.5mm stereo jack sockets. If you intend using an electret microphone, then you will also have to install a 2-pin socket strip to accept its connecting leads. Note that the electret microphone should *not* be connected while using an *external* microphone.

Installing the card socket

The memory card socket is mounted on the underside of the PC board – see Fig.4. This is an SMD, so you must carefully position it over its pads and solder one of the pins first to anchor it in position. Once that is done, you can solder the rest of the pins. Note that there are two mounting terminals on either side of the device that must also be soldered to matching pads near the front edge of the board (see Fig.4 and photo).

The initial assembly can now be completed by fitting four M3 x 12mm nylon spacers to form the mounts for the PC board. **DO NOT fit the ICs or the LCD panel at this stage. These parts are installed only after the supply rails have been checked and that step comes next.**

Power supply checks

You will need a 12V DC 300mA (or higher) regulated plugpack with a 2.5mm connector to power this project.

Before applying power, make sure that the LCD is unplugged and that no ICs have been fitted. That done, apply power and move switch S9 to its ON position (ie, to the right). Now, using a DMM, measure the voltage between the OUT and GND terminals of REG1 – you should get a reading of 9V. If not, switch off immediately and check for supply errors. If no voltage is present, then diode D9 may be reversed or the supply polarity could be incorrect.

Assuming all is OK, check the voltage on the OUT terminal of REG2. This time, you should get a reading of 5V.

Finally, check the voltage on the OUT terminal (ie, the centre terminal) of REG3. It should be close to 3.3V. If any of the above voltages is incorrect, disconnect power immediately and check your work.

Note: the OUT terminal of REG3 is the centre lead of the device. By contrast, the OUT terminal of both REG1 and REG2 is one of the outside leads – see Fig.1 for the pinouts.

Screen grab showing the playing view. The time since the beginning of the track and the volume level are shown. Note that the time will blink on and off if track is paused.

Screen grab showing file selection. You can scroll through the file system by using the Up and Down buttons and press Play when you are satisfied with your selection. The currently selected file is shown with '>'.

The previous directory is shown as '[..]'. You can press Play or Record to enter a directory. Note that directory names are enclosed in square brackets to differentiate them from normal files.

The playing view. The time since the beginning of the track, the sampling rate and whether the track is mono or stereo are shown. This view shows that the sampling rate is 44.1kHz and it is a stereo track that's being played.

The recording view. The time since the beginning of the track, the sampling rate and whether the track is mono or stereo are shown. This view shows that the sampling rate is 16kHz and that it is a mono track that's being recorded.

When playing a random selection through shuffle, this is the play screen shown. Notice the 'RND' indicator that's only shown in this mode.

A screen readout showing the size of the inserted memory card and the remaining free space on it. This screen is displayed once on startup.

Fig.5: this diagram show some typical displays on the LCD, together with accompanying explanations. The unit shows file names, time elapsed while playing, the recording source, volume, sampling rate, card size, free space and other information.

Trimming the 3.3V rail

If the 3.3V rail is more than 3.4V or less than 3.2V, you will need to change one or both of the values for R2 and R3. For example, if the voltage from REG3 is 3.17V, you will need to install a 10Ω resistor for R3 and this should bring it pretty close to 3.3V.

Alternatively, if the output voltage is 3.41V, you should change the value of R2 to 160Ω and R3 to 10Ω, giving a total value for R2 + R3 = 170Ω (or you could use 150Ω for R2 and 22Ω for R3). Again, this should bring the voltage from REG3 pretty close to 3.3V.

If all three supply voltages are now close to their nominal values, you can disconnect power and insert the four ICs in their sockets. These ICs should all be oriented correctly of course.

Installing the LCD module

The LCD module can now be installed. The SIL module is secured to the board on two M3 × 9mm tapped nylon pillars, as shown in Fig.3, while the alternative DIL module is secured using four M3 × 9mm tapped nylon pillars, ie, one at each corner (all the necessary mounting holes are on the PC board).

Your Digital Speech Recorder and Audio Player is now completed and ready for use.

You should transfer the audio WAV files you wish to play to an MMC/SD/SDHC card using your PC or Mac, making sure the card is formatted with a FAT/FAT32 file system. Once the memory card has been inserted in its socket on the underside of the PC board, you can apply power. The firmware should display the version on the LCD panel and then compute the free size on the memory card. Your player is then fully operational.

Configuring the unit

The Digital Speech Recorder can be used in either of two modes: normal or triggered.

By default, the unit works in normal mode. However, if you wish to configure it for triggered operation, you simply create a file 'trigger.txt' and place it in the root folder of the memory card you are using. You can do this using a card reader and a PC. The file need not contain anything – it just needs to be there (as an empty file).

The microcontroller will look for this file on boot up and switch the mode of operation to triggered if it is present. On the other hand, if this file is absent, the recorder boots for normal operation.

The differences between these two modes of operation are explained below.

Normal mode

In Normal operation, you begin by using the UP and DOWN buttons (S2 and S6) or the VOL UP and VOL DOWN

Configuring the software to suit the LCD module

If you look closely at the PC board for this project, you will notice that the DIL and SIL LCD modules are wired with their data lines 'transposed'. Basically, the D0 line on the SIL module is connected to the D7 line of the DIL (Jaycar) module, while the D1 line on the SIL module is connected to the D6 line of the DIL module and so on. This was done to simplify the PC board layout.

It means, however, that the firmware must drive these two LCD modules differently. As a result, the microcontroller must either be programmed with a SIL version if you are using the SIL LCD module or with a DIL version if you are using the DIL LCD module.

You can also toggle either version to drive the alternative module. This is done by holding down buttons S4 and S8 together while applying power.

Note that this needs only to be done once, as the new setting is stored in non-volatile memory.

If nothing appears on the LCD at initial switch-on, try adjusting the contrast (VR1). If that doesn't work, you may have the wrong software for your particular LCD module, so switch off and reapply power while holding down S4 and S8.

If you buy a kit, then the default will be correct for that kit supplier's LCD module.

buttons on the remote control to scroll through the file system on the card.

When you've selected the correct file, you simply press PLAY (S8) to play it. A screen grab showing a typical view of the file system is shown in Fig.5 (second from top). Of course, only two files are ever shown at any one time. A directory is indicated by its name being enclosed in square brackets. Press PLAY to enter a directory. The previous directory is shown as '[..]' – see Fig.5.

The delay in playing a new file is very small, of the order of a fraction of a second. This makes this project perfect for playing sound effects on demand.

Pressing SHUFFLE (S1) or FAST FF on the remote enters random shuffle mode. In this mode, there is an 'RND' indicator on the display and a random selection of tracks (eg, songs) is continuously played from the root directory. You exit this random shuffle mode by pressing STOP (S4).

Pressing REC MIC (S3) or REC LINE-IN (S5) starts a recording from the microphone or line input respectively. Alternatively, you can press the Record or Line buttons on the remote.

This close-up view shows how an on-board electret microphone can be installed (it plugs into a 2-pin header near the external microphone socket – but watch the polarity). Do NOT install this if you intend using an external mic.

When recording a file, the filename will be of the form rec???.wav with ??? a string of three decimal digits. The filename recorded will be shown when the recording is ended using either the STOP button (S4) on the board or the STOP button on the remote.

In practice, it's more complicated 'in the telling' than 'in the doing'. A few minutes spent pressing buttons will quickly reveal how it works.

Triggered Mode

In Triggered mode, you simply press one of the eight buttons to play the file 'rec00?.wav' where '?' is a digit from 1 to 8. For example, pressing S3 will play the file 'rec003.wav'.

You can also press the corresponding digits on the remote control to play each of these eight files.

Basically, the Triggered mode is useful for quickly playing back one of eight tracks (or messages) once they have been recorded. After recording the messages (using Normal mode), it's just a matter of copying a file called 'trigger.txt' to the root folder of the card as detailed above and restarting the Digtial Speech Recorder. *EPE*

The coming revolution

TechnoTalk

Mark Nelson

You can't buy memristors (yet) but you might well wish to. Memristors offer greater memory storage than current semiconductor solutions, require less energy and occupy a smaller footprint. In time, they could also substitute for the billions of transistors found in a modern microprocessor. In fact, they're every designer's dream, as Mark now explains.

EVERY so often, fantastic futures are forecast for new electronic technologies. Some make it big time – like the transistor, CMOS and surface-mount components – while others don't.

If nuvistors, fetrons, tunnel diodes and fluidics don't ring a bell with you, it's really little wonder, since they failed to fulfil their expectations. But currently there's universal interest in memristors, so let's concentrate on them.

Missing link discovered

The memristor promises to create a semiconductor revolution as significant as the transistor did in the 1950s. Observers consider it to be the 'missing link' in electronics, the up-to-now uninvented complement to the resistors, capacitors and inductors used in well-nigh every electronic product.

In essence, the memristor is a resistor with memory; applying an electric voltage to it will alter the degree to which it impedes electric current. And there's a bonus: a memristor can 'remember' that factor, even after the power is turned off.

This makes it a prime contender for memory that requires minimal energy to store information, just like the non-volatile Flash memory used currently. Unlike Flash, however, the memristor will offer significantly greater memory storage, run ten times faster and require ten times less energy and space.

In principle, the memristor could also be used in logic circuits, substituting for the billions of transistors in a modern microprocessor, but this will come only after significant further development. Other uses will doubtless be found, for experience tells us that the most valuable applications will most likely come from a young student who learns about these devices and then has an inspiration for something totally new.

Simpler in operation

In a *BBC News* interview, Steve Furber, professor of computer engineering at the University of Manchester, stated: 'Memristors are much simpler in principle than transistors. Because they are formed as a film between two wires, they don't have to be implanted into the silicon surface – as do transistors, which form the storage locations in Flash – so they could be built in layers in 3D. Of course, the devil is in the detail, and I don't think the manufacturing challenges have been fully exposed yet.'

This, of course, is true, and there's no way to compress the development time of a new technology. 'New' is a relative term, and the memristor model was first proposed by Leon Chua as long ago as 1971, when there was no method of achieving proof of concept of what he had already named the 'missing circuit element'.

The first actual memristor was demonstrated in April 2008 by electronics giant Hewlett Packard, but the real 'coming of age' occurred last year when HP and Korean memory manufacturer Hynix announced a joint effort to develop memristor memory chips. By 2013, the first products should be ready, known as resistive random access memory (ReRAM). This is designed to replace Flash memory and can also substitute for DRAM and hard drives, making it a new universal storage medium.

How does it actually work?

The Wikipedia definition explains that a memristor is a passive two-terminal electronic component whose resistance depends in some way on the amount of charge that has flowed through the circuit previously. When current flows in one direction through the device, the resistance increases; and when current is reversed, the resistance decreases, although never to zero or a negative level. The component retains its final resistance after the current ceases and when the flow of charge starts again, the resistance of the circuit will be the same as when it was last active.

It's these tiny read charges that provide access to a 'history' of the voltage applied previously. You might argue that batteries have memristance too, but they are not passive devices.

Machines that learn

In the longer term, memristors might enable computers to 'learn' what you want from them. HP scientist Jianhua Yang says, 'Any learning a computer displays today is the result of software. What we're talking about is the computer itself – the hardware – being able to learn.'

'This is not to say the computer would function like a human brain, but it could gain pattern-matching abilities, which would let it adapt its user interface based on how you use it. These same abilities make it ideal for such artificial intelligence applications as recognising faces or understanding speech.'

The name says it all

The name memristor is short for 'memory resistor', so named because its resistance varies according its 'memristance' function, providing access to a 'history' of previously applied voltage stored in minute read charges remaining in the device. The name, it has to be said, is more meaningful to the average person than 'transistor'.

Most people have a rather hazy idea of how and why the transistor got its name, so it's best to go to the man who named the device, John R Pierce of Bell Labs. He was the person who supervised the team which built the first transistor there.

Interviewed on the Public Broadcasting System in the USA, Pierce stated: 'The way I provided the name was to think of what the device did. And at that time it was supposed to be the dual of the vacuum tube. The vacuum tube had transconductance, so the transistor would have 'transresistance'. And the name should fit in with the names of other devices, such as varistor and thermistor. [So] I suggested the name *transistor*.'

Next step

Further development of memristors will rely in part on developing the best material implementation. HP is not alone in this quest, and IBM, HRL, Samsung and other research labs are also developing components based on a titanium dioxide substrate. However, manganite polymers and other substances are also being explored.

In 2009, Leon Chua, father of the memristor, wrote a paper with two co-authors that extended the notion of memristive systems to capacitive and inductive elements. It proposed the possibility of memcapacitors, and meminductors with memory properties dependant on the state and history of the system.

Whatever next?

The memristor has its own website at: **www.memristor.org**, while HP has produced a handy FAQ sheet that you can read at: **www.hpl.hp.com/news/2008/apr-jun/memristor_faq.html**.

By JIM ROWE

Input attenuator for the Digital Audio Millivoltmeter

If you'd like to be able to use our Digital Audio Millivoltmeter to measure AC voltages up to 140V RMS, this add-on project is the answer. It's a simple switched input divider that lets you add 40dB, 20dB or 0dB of attenuation ahead of the meter at the touch of a knob.

THE *Digital Audio Millivoltmeter* described in the March 2011 issue of *EPE* can measure signals over a 79dB range, from about 160µV (–76dBV) up to 1.41V RMS (+3dBV). This is fine for low-level measurements, but it does make the meter unsuitable for measuring higher level signals.

With the benefit of hindsight, we could have built a switched input divider right into the meter itself. However, this would have involved a tight squeeze to fit the additional switch and components into the PC board and box, and the front panel would have been very crowded as well.

To increase the measured voltage range, we have designed this little 'outboard' switched input attenuator. It's designed to be connected ahead of the Digital Audio Millivoltmeter's unbalanced input via a short BNC cable.

There's no need for cable swapping to remove it when you are measuring small signals because it incorporates a 'straight through' (0dB) switch position. So, once it's built and connected to the input of the meter, its own input connector effectively becomes the meter's unbalanced input.

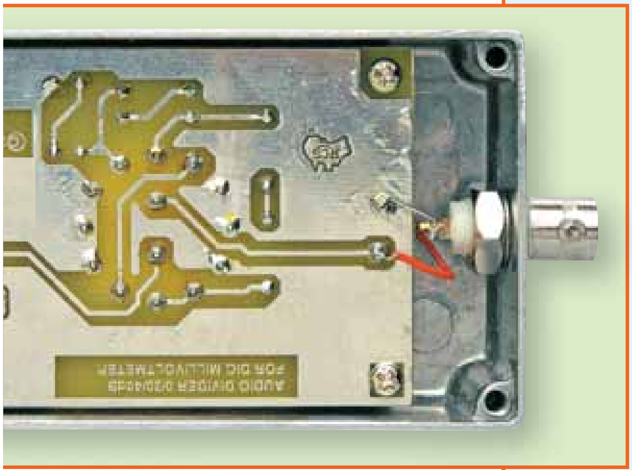
Simple circuit

There's very little in the attenuator, as you can see from the circuit schematic (Fig.1). A 2-pole switch is used to switch the input signal either straight through to the output (0dB) or via one of two taps on the resistive divider.

The upper tap gives a 10:1 division (–20dB), while the lower tap gives a 100:1 division (–40dB). As a result, the first position of the switch leaves the millivoltmeter's own ranges unchanged, while the next position effectively subtracts 20dB from the meter readings, and extends its 'full scale' reading to 14.1V RMS or +23dBV.

Similarly, the third switch position subtracts 40dB from the meter readings, and extends its measurement capability out to 141V RMS (+43dBV).

Note that the meter readings don't take this added attenuation into account, because there's no way for the PIC micro inside the meter to know how much extra attenuation is being applied. So you have to add the 20dB



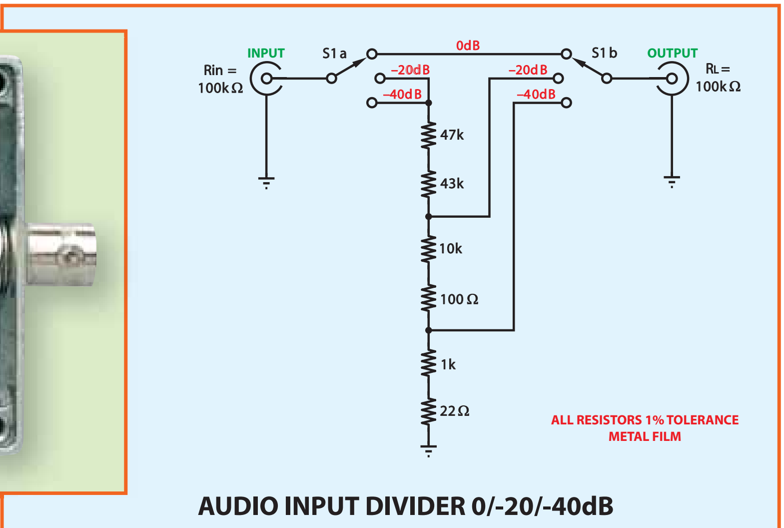


Fig.1: the circuit is simply a switched resistive attenuator network, with double-pole switch S1 selecting between the 0dB, –20dB (10:1 division) and –40dB (100:1 division) positions.

or 40dB to the readings yourself and/or multiply the millivolt readings by either 10 or 100 as appropriate. That doesn't involve a great deal of mental maths though.

Now, before you ask, we'll clear up a few points about the resistor values used in the divider. Do they make allowance for the shunting effect of the meter's own input resistance? Yes, they do.

If you care to work it out, you'll find that the division ratios of 10:1 and 100:1 are only correct when the output of the attenuator is loaded with 100kΩ (ie, the input resistance of the millivoltmeter). The ratios are then within 0.1% of their nominal 10:1 and 100:1 values – which is close enough considering we are using 1% tolerance resistors.

The input resistance of the input divider/millivoltmeter combination also remains very close to the nominal 100kΩ figure for the meter itself. Clearly, it's exactly the same in the 0dB switch position, but even in the other two positions it is still within 2%.

Construction

Most of the parts are mounted on a small PC board measuring 76mm × 53.5mm and coded 811. This board is available from the *EPE PCB Service*. The board is designed to fit inside a standard small diecast aluminium box measuring 111mm × 59mm × 30mm. This box provides shielding and physical protection. It also matches the larger diecast box used for the millivoltmeter itself.

There's plenty of space inside the box for the BNC input and output connectors, which are both insulated single-hole mounting types. As shown in one of the photos, the board assembly itself mounts centrally in the bottom of the box and is secured via four M3 × 15mm tapped spacers. Note that metal spacers and screws must be used to secure the board, because one of the spacers is used to connect the box to the PC board earth copper.

Note, the other three spacers and screws must NOT make contact with the board's earth copper. This is done to prevent the formation of earth loops.

Fig.2 shows the parts layout on the PC board. There's just the six resistors

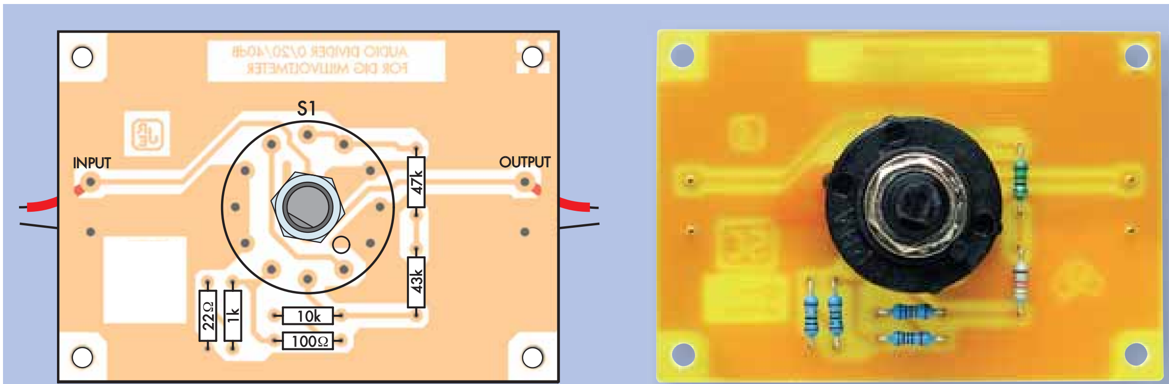


Fig.2 (left): position the parts on the PC board as shown here and install PC stakes on the copper side at the external wiring points. The completed board (right) – should only take a few minutes to assemble.

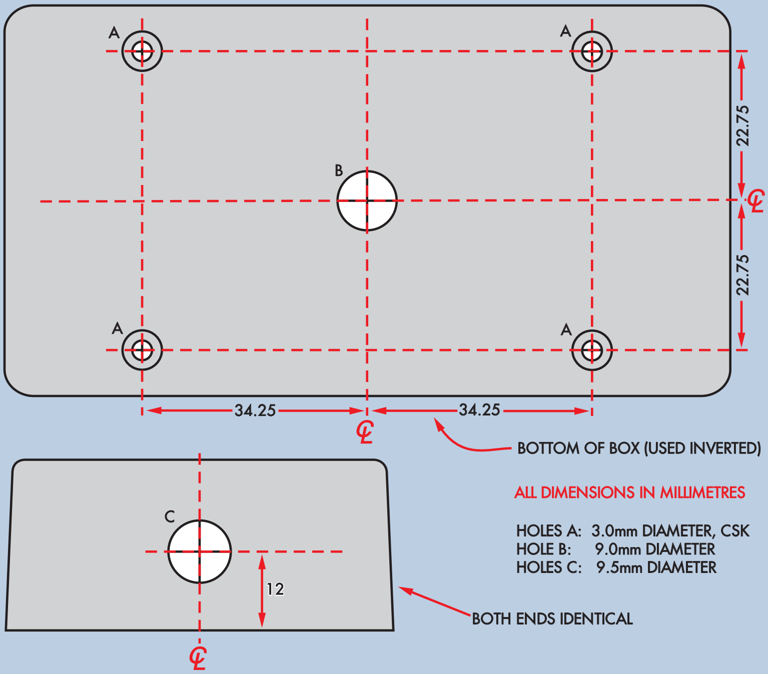


Fig.3: this diagram shows the drilling details for the metal case. Note that the bottom of the box is used as the front panel, so be sure to drill holes 'A' and 'B' in the base (NOT the lid).

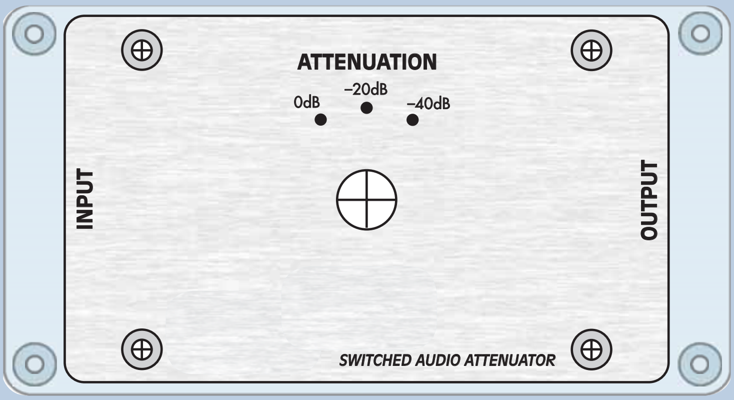


Fig.4: full-size front panel artwork is attached to the base of the case. It can be photocopied and glued to the box base (front panel).

Parts List

1 PC board, code 811, available from the *EPE PCB Service*, size 76mm × 53.5mm
1 diecast aluminium box, size 111mm × 59mm × 30mm
1 2-pole 6-position rotary switch, with adjustable end-stop
1 small instrument knob
2 BNC connectors, insulated single hole mounting
4 M3 x 15mm tapped metal spacers
4 M3 x 6mm screws, pan head
4 M3 x 6mm screws, countersink head
4 1mm PC board terminal pins
4 stick-on rubber feet
Light-duty hook-up wire

Resistors (0.25W 1%)

1 47kΩ	1 1kΩ
1 43kΩ	1 100Ω
1 10kΩ	1 22Ω

and the switch, so assembly will only take a few minutes to complete. Cut the switch shaft to a length to suit the knob before fitting it to the PC board.

The connections between the input and output BNC connectors and the PC board are made via short lengths of hookup wire. We fitted PC board pins to the board (from the copper side) to make these connections a little easier.

Wiring up the attenuator should be very easy – see Fig.2 and Fig.5. The whole job should take you no more than an hour or so, including the time to drill and ream the holes in the box.

Boxing up

The drilling details for the case is shown in Fig.3. **Note that the case is used inverted, so that the base becomes the front panel (do NOT drill the lid).** Use a small pilot drill to start

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❏	1	43kΩ	yellow orange orange brown	yellow orange black red brown
❏	1	10kΩ	brown black orange brown	brown black black red brown
❏	1	1kΩ	brown black red brown	brown black black brown brown
❏	1	100Ω	brown black brown brown	brown black black black brown
❏	1	22Ω	red red black brown	red red black gold brown

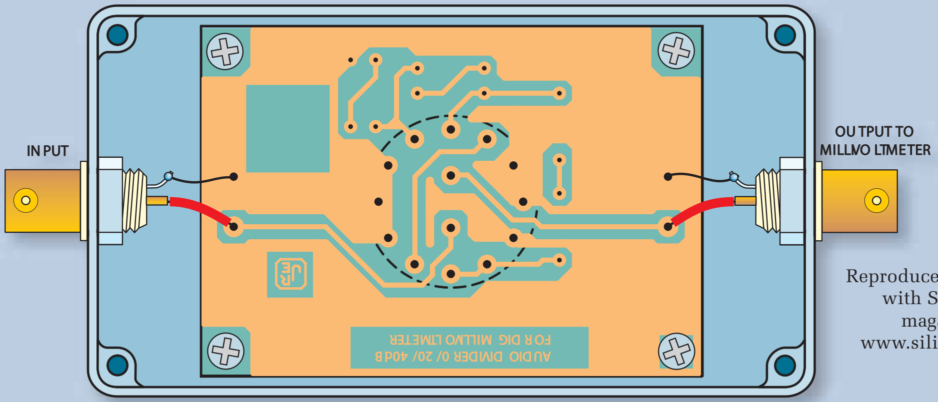


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Fig.5: the PC board is fitted with M3 × 15mm tapped spacers and mounted upside down in the base of the case. The BNC sockets are then wired by running leads to the PC stakes on the board.

the larger holes, then carefully enlarge them to the correct size using a tapered reamer.

Fig.4 shows a full-size artwork for the attenuator's front panel. It can be photocopied onto a piece of adhesive-backed label. This can then be covered with self-adhesive clear plastic film (to resist discolouration due to finger grease) and attached to the base (use a thin smear of silicone sealant to attach the label if it doesn't have an adhesive backing). Cut out the holes for the switch and the PC board mounting screws using a sharp hobby knife.

Next, move the end-stop washer on the rotary switch to the correct location for three switch positions. Do not initially refit the nut after doing this – just refit the lockwasher for the time being (the combined height of the switch and lockwasher above the PC board is very close to 15mm, so they match the four M3 × 15mm tapped mounting spacers).

Countersink-head M3 × 6mm screws should now be used to secure the four M3 × 15mm tapped spacers to the base. The PC board can then be fitted in position and secured using M3 × 6mm pan-head screws. That done, fit the nut to the switch and attach the knob to the switch shaft.

Finally, secure the lid in position (this now becomes the base of the case). It's also a good idea to fit four small adhesive-backed plastic or rubber feet to the box lid, to prevent scratches to bench-tops or any other surface the device is placed on.

That's it. Once your add-on attenuator is finished, your Digital Millivoltmeter will be able to make measurements over a 96dB range: from 160μV to just over 140V RMS. ***EPE***

A Deluxe 3-channel UHF Rolling Code Remote Control

This high-security 3-button UHF transmitter and receiver can be used for keyless entry into homes and commercial premises, and for controlling garage doors and external lighting.
Three separate outputs on the receiver can be used to activate various electrical devices, such as a door strike, a motorised garage door and 230V AC lights. Up to 16 transmitters can be used with one receiver, so it's even suitable for a small business.

MAYBE you have been thinking of building a low-cost remote switching circuit, but have been put off the simpler ones because of concerns over security. If so, then this project is for you. It's a completely new design for applications where you want high security and the ability to control more than one device.

For example, you may want to control a garage door (one or two) and your house lights to illuminate the driveway or entry. Or maybe you want to control the garage door, the driveway lights and have keyless entry into your home.

After all, you already have keyless entry into your car; why should you have to fumble with keys to open your front door? In fact, there are already commercial keyless entry systems for homes. Why shouldn't you have it too; and at lower cost?

Or how about this scenario? Say you have a two-car garage, in which the cars are tightly parked with not enough room for the passenger to get in before you drive out.

So you turn on the lights in the garage and outside, reverse your car out, the passenger gets in and you then use the 3-button transmitter to close the garage door, turn off the lights and drive away. When you return, you can turn on all the lights, your passenger alights and you can drive into the garage; all very civilised and convenient. And then you could also have keyless entry into the house itself!

Rolling code for high security

As with any type of lock, it is important that no one can gain access without the correct key.

For UHF remote control systems, the 'key' is a specific code sent by the transmitter to the receiver. Usually, this code is a long sequence of on and off signals sent in a specific sequence and over a set period. The code must be correct in order for the receiver to allow access.

It's effective – but there's a problem. The coded signal is transmitted over a relatively wide area each time it is used to gain access. Intruders have, in the past, used a radio receiver and recorder to intercept the signal as the transmitter sends it. The intercepted signal could then be retransmitted to gain access.

Another method they've used is to continuously generate access codes with a computer and send them one after the other to the receiver. Eventually, the code is broken and access is possible.

Neither of these tampering methods will work with a 'rolling code' or 'code-hopping' system. In a rolling code system, the code transmitted is altered after each transmission.

So intercepting the signal and resending the signal will not enable access because the door lock is now expecting a different code. The code is based on an algorithm (calculation) that both the transmitter and receiver have in common. This is such a good system that many cars now have rolling code keyless entry systems.

The code possibilities of a rolling code system usually run into the trillions. This renders any attempt to break the code totally unrealistic. The odds of picking a correct code at random for our rolling code transmitter, for example, is one in 2.8 trillion. Even then, the code needs to be sent correctly at the required data rate, with the correct start and stop bit codes and other transmission requirements. As we said, rolling code means high security!

Features

Our *UHF Rolling Code Security System* has two parts: a keyfob-style transmitter and a separate receiver.

The keyfob has three pushbutton switches and an acknowledge LED that briefly lights up each time one of the switches is pressed. Up to 16 separate keyfob transmitters can be used with one receiver.

The receiver has three relays that can be switched independently using the three switches on the keyfob transmitter(s). Each relay can be set to toggle on or off, or remain energised for a set period. This can be adjusted from 0.26 seconds to 4.4 minutes.

Part 1

By
JOHN CLARKE

Features

Transmitter

- Three function buttons
- Coding randomisation
- Rolling code UHF transmission
- Registering ability
- 16 identifications encoding
- 12V remote control battery operation
- Keyfob case
- Acknowledge LED indication

Receiver

- 12V DC plugpack operation
- For use with up to 16 separate transmitters
- 3 independent 230V AC rated relay contact outputs
- Door strike driver output
- Momentary or toggle operations for each output
- Momentary outputs adjustable in duration from 0.26 seconds to 4.4 minutes
- Acknowledge, power and output LED indicators
- Look-ahead feature for 100 codes when transmitter code is ahead of receiver code
- Lockout available for any registered transmitter
- Local control of outputs available

Specifications

Transmitter

Battery: ....12V 55mAH (A23 type)
Battery life: .... >2.5 years expected with typical use
Standby current: .... Typically 2.5μA with switches open (drawing 22mAH/year from battery)
Code transmit current: ...... 3mA average over 160ms (133nAH / transmission drawn from battery)
Register transmit current:.. 3mA average over 2.75s
Randomisation current: 3.3mA
'Stuck switch' current: ...... 220μA (after transmission is ended if a switch is kept pressed)
Code transmission rate:...... 1.024ms/bit (1k baud)
Encoding: .... A high (or a 1 bit) is transmitted as a 512μs burst of 433MHz signal, followed by 512μs of no transmission. A low (or 0 bit) is transmitted by a 512μs period of no transmission, followed by a 512μs burst of 433MHz signal.
Rolling code: .... Sends four start bits, an 8-bit identifier, the 48-bit code plus four stop bits. The start bits include a 16.4ms gap between the second start bit and the third start bit. Code scramble value is altered on each transmission.
Register code:.................... Sent as two blocks. Block 1 sends four start bits, the 8-bit identifier, a 32-bit seed code and four stop bits. Block 2 sends four start bits, a 24-bit multiplier, the 8-bit increment and 8-bit scramble values, and four stop bits. The start bits include a 16.4ms gap between the second start bit and the third start bit.
Code randomisation: .... Alters the multiplier values, the increment value, the scramble value and the seed code at a 40μs rate.
Transmission range: .... 40m minimum

Receiver

Power: .... 12VDC at 150mA. (If using an electric door strike up to 12V DC at 1A intermittent)
Standby current: ....14mA (168mW) with all relays off. 150mA (1.8W) with all 3-relays and indicator LEDs lit
Relay contact rating: ....10A @ 240V AC
Momentary period: .... When set to momentary operation, each output is adjustable from 0.26s to 2s in 0.26s steps, then in 1s steps to 10s and in 15s steps to 4.4 minutes. (See Table 2.)

The relay outputs can switch up to 10A and 230V AC. For use with an electric door strike, the third output on the receiver can provide switched power directly, rather than having to wire up through relay contacts and 12V power.

The facility to setup for momentary or toggle action for the three outputs is provided with three pushbutton switches, a small rotary switch and three trimpots.

Indicator LEDs are included for power indication, relay on or off, and receive acknowledgement. The three pushbutton switches can also double up to function as local controls to switch the relays instead of using the UHF remote control.

Security and registration

Each keyfob transmitter must be allocated an identity number from 0 (zero) through to 15. This is set by coding links on the PC board. Then the initial rolling code needs to be randomised and the algorithm parameters set so that they are unique for each transmitter.

Finally, each transmitter is registered, and this involves sending a synchronising code to the receiver from the transmitter when the receiver is set in its registration mode. As we said before, this can be done for 16 transmitters, and each will operate independently with the receiver.

Also included is a facility to lock out a particular transmitter after it has been registered. This is useful if a transmitter has been lost and you do not wish it to be useable with the receiver. If the lost transmitter is found then it can be easily re-registered.

When the identity of the lost transmitter is not known, then all transmitters can be locked out and ones that are in use can be re-registered.

Another use for this lockout facility is where people hire a public hall for a function, are lent a keyfob transmitter to gain entry (via an electric lock) and turn off any alarm system. If the keyfob is not returned, it can be locked out to prevent future security breaches.

Transmitter circuit

The circuit diagram for the *3-channel UHF Rolling Code Keyfob Transmitter* is shown in Fig.1. There is not a lot to

The keyfob transmitter, shown above about life size, has three buttons, each of which controls a relay in the receiver. At bottom left is an LED that briefly flashes when any button is pressed, telling you that the battery is still OK.

At right is an oversize view of the completed transmitter inside the open keyfob case. The green PC board is the 433MHZ UHF transmitter module itself.

the circuit, with just a PIC16F88-I/P microcontroller (IC1), a 433MHz UHF transmitter module and a surface-mount 5V regulator (REG1) as the major parts.

IC1 is normally kept in sleep mode, with its internal oscillator stopped and most internal features switched off. In this state, it draws a typical standby current of 0.6μA from the 5V supply (which is derived from a miniature 12V battery).

Switches S1 to S3 and the jumper links LK1 and LK2 connect to the RB6, RB5, RB7, RB0 and RB4 inputs. Each input is normally held high by an internal pullup resistor to the 5V rail. A closed switch will bring the respective input low (0V). Similarly, when LK1 is closed, the RB0 input will be held low. RB4 is brought low only when LK2 is in and switch S3 is pressed. IC1 is programmed to wake up from its sleep condition when any one of the RB4 to RB7 inputs change in level, or the RB0 input goes to 0V.

When IC1 wakes up, it starts running its program. If RB0 is low, the routine to randomise the parameters is run. If RB4 is low, the registration codes are transmitted, and if RB5, RB6 or RB7 is low, as when one of the keyfob buttons is pressed, it sends the normal rolling code.

The rolling code and registration codes are sent via the 433MHz transmitter module. This module is powered via the paralleled RA3 and RA4 outputs of IC1, which go high to provide a nominal 5V to the V_{CC} input of the module. The code signal is applied to the data input of the module from the RA2 output of IC1.

LED1 is driven via the RB3 output and is modulated at the code transmission rate of about 1kHz. The LED acts as a transmit indicator.

Inputs RA1, RA0, RA7 and RA6 can be tied to 0V or to the 5V supply rail via links on the PC board. These select the identity of the transmitter. With all inputs connected to 0V, its identity is '0'. When all inputs are tied to 5V, the identity is '15'. Various combinations of high and low connections for these inputs select the other identities from 1 to 14.

When the selected software routine is completed, IC1 returns to sleep mode.

First, if UHF transmission was involved, supply to the UHF transmitter module is removed by taking the RA3 and RA4 outputs and the data line at RA2 to 0V. LED1 is switched off with a low at RB3.

So, IC1 returns to the sleep mode, when the RB0 and RB4 to RB7 inputs are high, with open links and switch connections.

Flea-power regulator

Putting the micro (IC1) to sleep for most of the time is useful for keeping battery drain to the minimum, but that still leaves the quiescent current of the regulator, because it needs to continuously provide 5V supply for IC1.

A standard low-power 78L05 regulator is out of the question, as it typically draws 3mA quiescent current. Better still is the micropower LP2950 voltage regulator, which has a 75μA quiescent current (typical).

But even with 75μA quiescent current, the battery will be flat after only 733 hours, or 30 days. The solution was to use Microchip Technology's MCP1703T-5002E/CB 3-terminal regulator, which draws a mere 2μA. This regulator current, combined with the micro's quiescent current when it is asleep has the whole circuit drawing about 2.6μA.

We measured the standby current draw of our prototype circuit and found that it consumed 2.5μA of current from a fresh 12V battery. Measuring this current was easy. A 1kΩ resistor was temporarily placed in series with the battery supply and the voltage drop across this resistor was measured. As we measured 2.5mV, the current is then calculated as 2.5mV/1kΩ or 2.5μA.

During a transmission of a rolling code command, the current will briefly rise to about 3mA. If you hold one of the buttons down after the transmission is complete, the current will be about 220μA. This is due to current flow in the switch pull-up resistor that connects from the 5V supply to 0V via the closed switch.

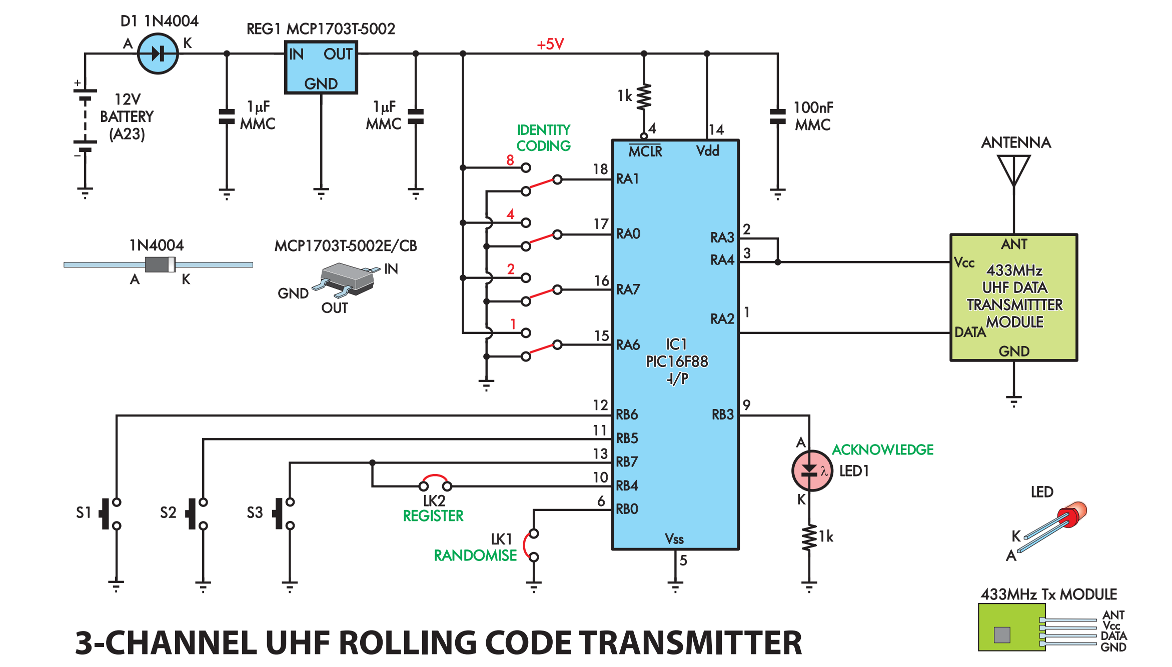


Fig.1: the transmitter is based on a PIC16FBB-I/P chip and a commercial 433MHz UHF data transmitter. Don't substitute REG1 with a conventional 5V regulator – even the low-power devices will quickly flatten the battery.

Battery life is expected to be more than 2.5 years, after which the 12V battery will have discharged down to 6V.

The transmitter circuit will continue to operate even at this low voltage – and this takes into account the nominal 600mV drop across reverse polarity protection diode D1. In fact, the regulator can operate down to 5.150V at its input and still maintain a 5V output. The input and output of REG1 are decoupled with 1μF monolithic ceramic capacitors. The regulator is designed to be stable with between 1μF and 22μF of capacitance on its output.

The effective series resistance (ESR) of the capacitor can range from 0 to 2Ω, so ceramic, tantalum or electrolytic capacitors can be used. IC1's supply is also decoupled with a 100nF monolithic ceramic capacitor.

Receiver circuit

The Receiver also uses a PIC16F88-I/P microcontroller (IC1) (see Fig.2). The UHF receiver module has a substantial on-board coiled wire antenna input to provide a very good reception range.

When no signal is present, the receiver's output signal is random noise that is caused by the module's automatic gain control (AGC) being set at maximum. Upon reception of a 433MHz signal, the receiver's gain is reduced for best reception without overload, and the coded signal from the data output of the module is applied to the RA2 input of IC1. LED4 indicates whenever a valid signal is received.

The RA4, RA6 and RA1 outputs of IC1 each drive a transistor and relay. When RA4 goes high, it turns on transistor Q1, which pulls in Relay1 and LED1 lights up. Diode D1 clips spike voltages at the collector (C) of Q1 when the relay switches off. The relay contacts are rated at 10A and 240V AC, and can be used to control 230V AC lights if required.

Relay operation can be either momentary or toggle. Toggle operation means that the relay switches on with one press of switch S1 on the transmitter keyfob, and switches off when S1 is pressed again. Momentary operation has the relay switch on for a short preset period of time.

For Relay1, the momentary period is set using the trimpot VR1. The trimpot wiper (moving contact) can be adjusted from 0V through to 5V, and this voltage is monitored at the AN3 input of IC1 to give the actual period, which ranges from 0.26 seconds to 4 minutes 24 seconds.

The other two relays operate in a similar manner, with LED2 and LED3 indicating when they are on. Similarly, VR2 and VR3 set the momentary periods for Relay2 and Relay3.

Note that transistor Q3, used to switch Relay3 is a power Darlington. This allows it to drive an electric door strike (which may require 800mA or so) as well as the relay.

Dual function switches

Switches S1, S2 and S3 have different functions, depending on whether link LK1 is in or out of circuit. When LK1 is out of circuit, the RA5 input is held high via a 33kΩ resistor to the 5V supply, and switches S1, S2 and S3 can then be used to operate the relays directly. Hence, S1 operates Relay1, S2 operates Relay2 and so on.

Whether each relay operates in toggle or momentary mode depends on how it has been previously set.

When LK1 is placed in circuit, S1, S2 and S3 perform a different function. S1 does the lockout function, S2 sets toggle or momentary operation and S3 does keyfob registration.

BCD rotary switch

The on-board BCD rotary switch (S4) has 16 positions, labelled 0-9 and A-F. This switch is only applicable to the lockout and momentary/toggle selections; it plays no part in the keyfob transmitter registration.

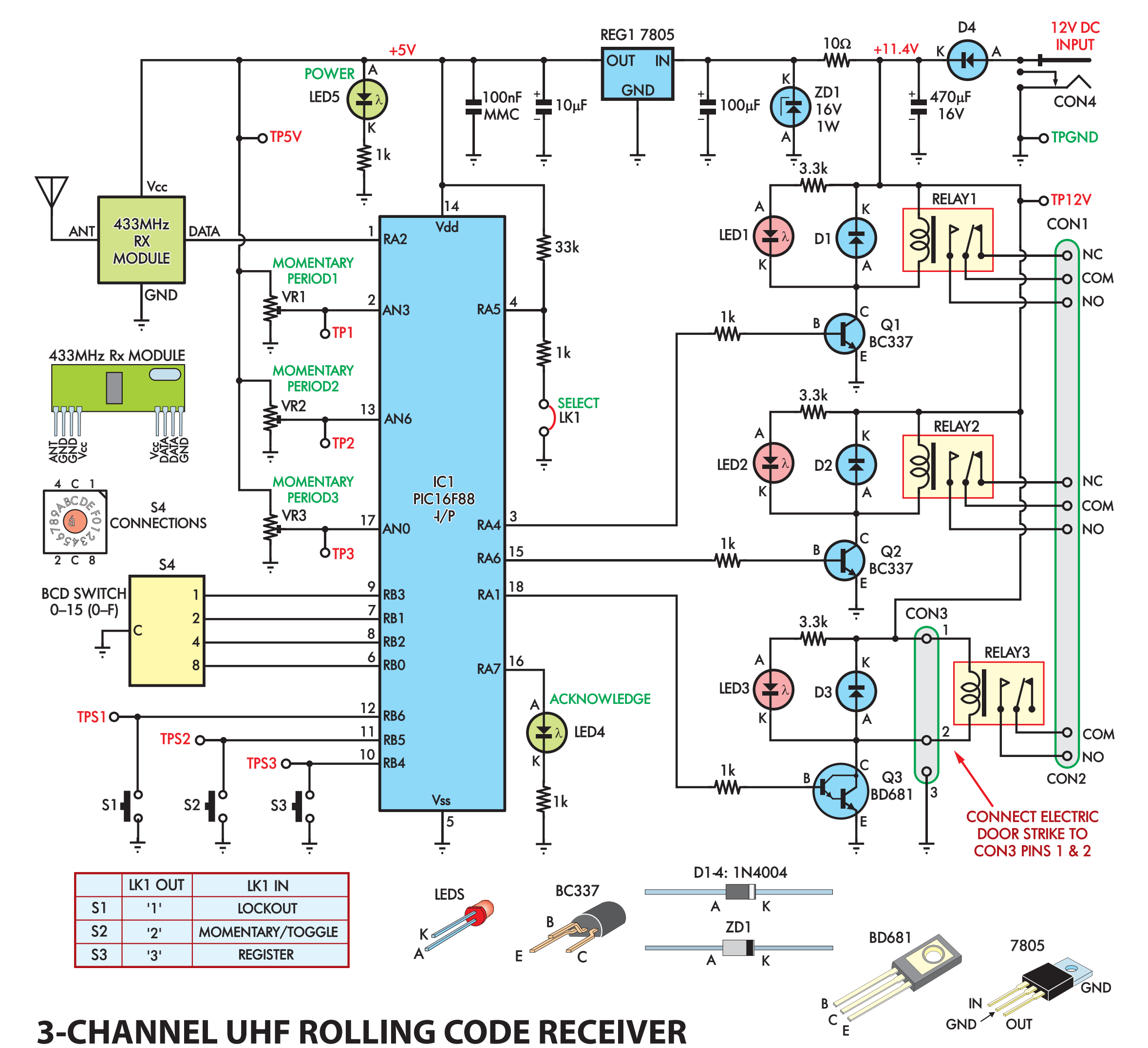
The BCD switch has four outputs that connect to the RB3, RB1, RB2 and RB0 inputs of IC1. They are normally held high via internal pull-up resistors in IC1 unless an input is held low via a closed contact in the switch. When the BCD switch is set at 0, all four inputs are held high. Position 1 on the switch has the '1' output at RB3 pulled low. Position 16 (or F) sets all switch outputs at 0V.

Also in the settings mode with LK1 in circuit, pressing S3 places the program in IC1 ready to accept the registration signal from a transmitter. S1 provides the lockout function.

Pressing S1 will prevent the transmitter from operating the receiver. The transmitter to be locked out is identified by the number selected with BCD1. Similarly, for the momentary/toggle function, the position of BCD1 determines the output that will be changed from momentary to toggle, or toggle to momentary when S2 is pressed. BCD1 position 1 changes output 1, position 2 changes output 2 and position 3 changes output 3.

Power

The circuit is powered by a 12V DC plugpack. Reverse-polarity protection is provided by diode D4, while the



	LK1 OUT	LK1 IN
S1	'1'	LOCKOUT
S2	'2'	MOMENTARY/TOGGLE
S3	'3'	REGISTER

3-CHANNEL UHF ROLLING CODE RECEIVER

Fig.2: the receiver is not dissimilar to the transmitter, and is based on the same PIC. The main difference is in the coding arrangement (S4) and the relays, which can be used to switch just about anything, mains (up to 10A) or low voltage. If used to control a door strike, Relay 3 isn't required – it can be switched directly via the Darlington (Q3).

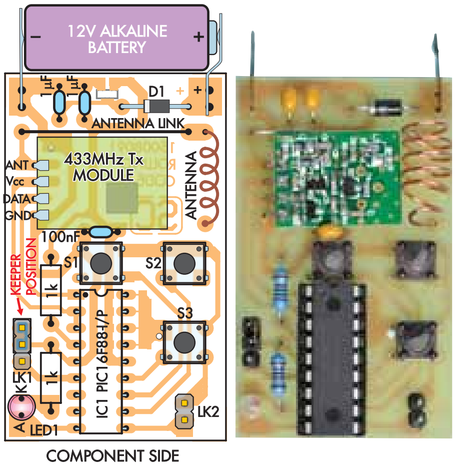
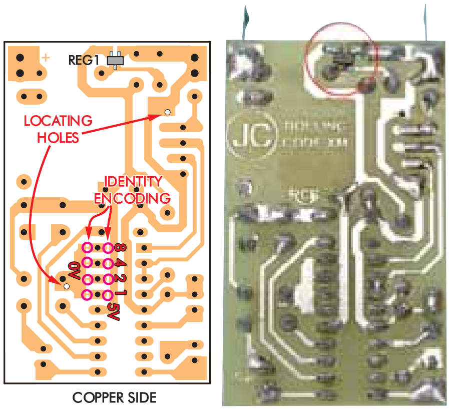


Fig.3 (left) shows the component side of the transmitter PC board. The UHF data module lies flat on the main PC board with its antenna, comprised of a short length of PC board track, a wire link and a wire coil.

Fig.4 (right) shows the under-side of the PC board, showing the identity coding links and the two locating holes. REG1, an SMD device, is also mounted on the copper side.



7805 3-terminal 5V regulator, REG1, is protected against excessive input voltage by Zener diode ZD1.

A nominal 12V rail supplies the three 12V relays. It is labelled as 11.4V on the circuit diagram (12V – 0.6V drop across D4), but the actual voltage could be higher, depending on the plugpack and power drawn from the plugpack. REG1 supplies IC1 and the UHF receiver module. A 100μF capacitor decouples the supply to REG1, while a 10μF capacitor bypasses the regulator output. LED5 indicates power is on.

Software

The software program files for the transmitter and receiver PICs are available from the *EPE* website at: **www.epemag.com**.

Construction

We'll begin construction with the keyfob transmitter. It is built using a 34mm × 56mm PC board, code 816. This board is available from the *EPE PCB Service* as a pair with the receiver board.

The assembled PC board is designed to fit into a Teco type-11 keyfob case with three buttons. The case is supplied with two battery contacts, a key ring loop, three switch caps and a case-securing screw.

Start by checking the PC board for correct sizing in the box. The edges of the PC board may need to be trimmed with a file if it has not been cut to the correct size. Note that the base of the case has a + and – polarity indicator for the battery terminals at its top end, while the PC board should fit neatly into the lower end of this case.

The case has two 1mm-diameter locating protrusions moulded into the base. These line up with the holes on the PC board when it is correctly fitted. Take care not to damage them – don't apply excessive force, or the pins will be bent or squashed.

Check the holes are correct with 1.25mm holes drilled for the battery terminals. Check that the copper pattern is intact with no breaks in the copper tracks or hairline shorts between copper areas; repair if necessary.

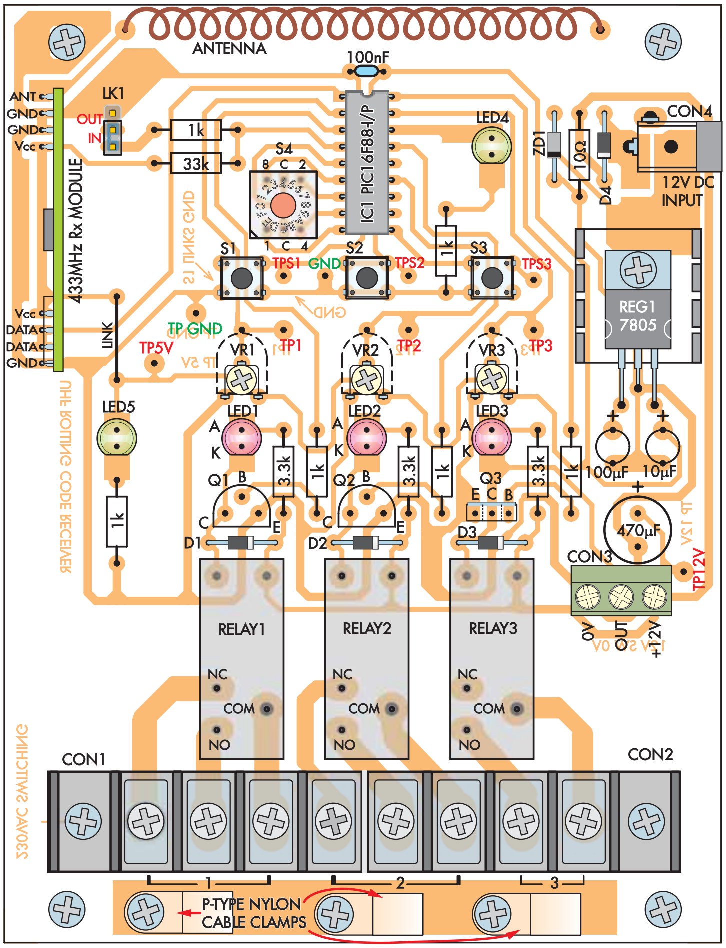


Fig.5: the receiver PC board. Everything is mounted on-board, with a similar coiled-wire antenna at the top of the board.

Identity coding

On the underside of the PC board are the identity encoding linking selections. The default setting is set for identity 0, where the ‘8’, ‘4’, ‘2’ and ‘1’ connections are tied to the 0V track with narrow PC tracks. If you are building just one transmitter there is no need to change these settings; it is only when more than one transmitter is required to work with the receiver that each transmitter requires a different identity. To set a different identity, use table 1 as a guide to setting the linking.

For example, to set identity 1, the ‘1’ connection has to be tied to 5V with the ‘2’, ‘4’ and ‘8’ connections left tied to 0V. To connect the ‘1’ connection to the 5V rail, the narrow track connecting to the 0V rail has to be broken with a hobby knife or engraving tool, and a solder bridge applied between the terminal and the 5V rail track. Make sure the 0V and 5V supply are not shorted together by connecting both these supply rails to the one connection.

Identities available are from identity 0 to identity 15. Identities 10 to 15 are the letters A to F respectively. We mention the A to F values because the lockout switch on the receiver is labelled with these hexadecimal numbers instead of decimal – to lockout a transmitter identity on the receiver you must match the switch setting with the identity value.

It is a good idea to write the actual identity of each transmitter on the rear of the keyfob case. This will make it easier to determine any lost transmitter identity so that it can be locked out.

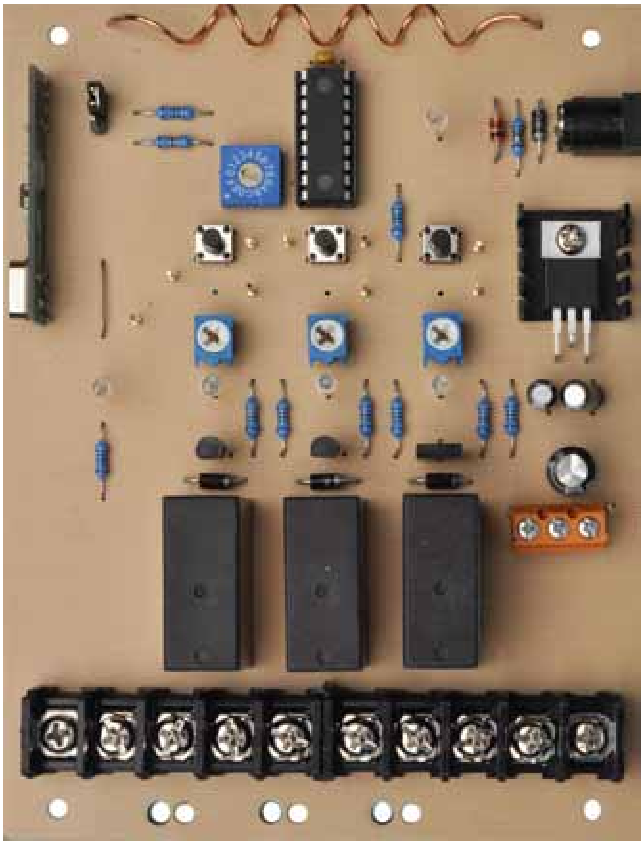
Con1 and Con2 are actually two 4-way barrier terminals, with one mounting hole cut off each end and the two halves glued together, as you can see here. Hot-melt glue holds them together while soldering and bolting in place (which takes most of the strain anyway). Note that these are actually panel-mounting types, which we made fit – the right ones, with PC pins instead of solder tags, which were out of stock at the time. You should use the *PC-mounting* type.

Regulator REG1 mounts on the copper side of the PC board. This is a surface-mount device, but it only has three leads, so is quite easy to solder in place. Position the device over the copper lands as shown on the underside overlay diagram (Fig.4) and solder just one of the leads to the PC board. Check the device is still located correctly before soldering the remaining pins. If you need to realign the device, it is much easier when only one pin is soldered. Use solder wick to help remove it – don’t try prising it off while heating the pins, as it is easy to damage either the pins or the copper lands underneath.

The topside of the PC board can now be assembled with the remaining components. Start with the wire link that acts as part of the UHF antenna. This is made from a 30mm length of 0.7mm tinned copper wire and is stretched as a straight wire between the two PC pads and soldered in position. We’ll look at the remainder of the antenna (the coil) shortly.

Now insert the IC socket, taking care to place the notched end toward S1 as shown. Make sure the socket is fully seated onto the PC board before soldering the pins. Don’t insert the IC just yet.

Switches S1, S2 and S3 are mounted fully seated onto the PC board. When soldering, be sure the locator hole near to S3 is not soldered, but is left clear of solder. Also, install the two 1kΩ resistors and diode D1 (which of course must be oriented correctly). Similarly, LED1 must go in the right way around – so that its anode, the round edge/longer lead, is oriented toward the lower edge of the PC board. The LED mounts right down on the PC board.



Here’s a matching photo to help get everything where it should be. In the receiver, the UHF module mounts at right angles to the board...

... as shown in this close-up photo. Make sure it goes in the right way around.

Parts List – Deluxe Rolling-Code UHF Remote Control

Transmitter

*1 PC board coded 816, size 34mm × 56mm
1 keyfob case with 3-buttons
(Teko type-11 No.11123.4) (supplied with battery contacts, key ring loop, 3-switch caps, LED diffuser and a securing screw)
1 433MHz UHF transmitter module
(Jaycar ZW-3100 or equivalent)
1 12V alkaline remote control battery
(Energizer A23 or equivalent)
1 DIP18 IC socket
3 SPST micro tactile switches, vertical mount with 3.5mm actuator (S1-S3)
(Jaycar SP-0602 or equivalent)
1 3-way 2.54mm spacing pin header
1 2-way 2.54mm spacing pin header
1 2.54mm jumper shunt
1 35mm length of 0.7mm tinned copper wire
1 138mm length of 0.63mm enamelled copper wire

Semiconductors
1 PIC16F88-I/P programmed microcontroller (IC1)
1 MCP1703T-5002E/CB 5V regulator (SOT-3 package) (REG1)
1 3mm green LED (LED1)
1 1N4004 1A diode (D1)

Capacitors
2 1μF monolithic ceramic
1 100nF monolithic ceramic

Resistors (0.25W 1%)
2 1kΩ

* Available as a pair from the *EPE PCB Service*

Receiver

*1 PC board coded 817, size 110mm × 141mm
1 IP65 sealed polycarbonate box with clear lid, size 171mm × 121mm × 55mm
1 433MHz UHF receiver module
(Jaycar ZW-3102 or equivalent)
1 0-F BCD rotary switch (BCD1)
(Jaycar SR-1220, Altronics S 3000A or equivalent)
3 SPST micro tactile switches vertical mount with 6.0mm (or similar) actuator (S1-S3)
(Jaycar SP-0603 or equivalent)
3 12V SPDT relays with 10A 240V AC contacts (RLY1-3) (Jaycar SY-4050 or equivalent)
2 4-way PC mount terminal barriers with transparent cover and 9.5mm spacing (CON1)
(Jaycar HM-3162 or equivalent)
1 3-way screw terminals with 5.08mm pin spacing (CON3)
1 3-way pin header with 2.54mm pin spacing
1 2.54mm jumper shunt
1 30mm length of 0.7mm tinned copper wire
1 157mm length of 1mm enamelled copper wire
3 P clamps for 5mm cable
3 Cable glands (3-6.5mm diameter cable)
1 18-pin DIL IC socket
1 mini finned heatsink 19mm × 19mm × 9.5mm
1 2.5mm PC mount DC socket (CON2)
10 PC stakes
2 M4 × 15mm screws
3 M4 × 10mm screws
5 M4 nuts
1 M3 × 10mm screw
4 M3 × 6mm screws
1 M3 nut
3 M4 washers
2 M3 washers

Semiconductors
1 PIC16F88-I/P programmed microcontroller (IC1)
1 7805 5V regulator (REG1)
2 BC337 *NPN* transistors (Q1,Q2)
1 BD681 *NPN* Darlington transistor (Q3)
3 red 3mm LEDs (LED1-LED3)
2 green 3mm LEDs (LED4,LED5)
4 1N4004 1A diodes (D1-D4)
1 16V 1W Zener diode (ZD1)

Capacitors
1 470μF 16V PC electrolytic
1 100μF 16VW PC electrolytic
1 10μF 16VW PC electrolytic
1 100nF monolithic ceramic

Resistors (0.25W 1%)
1 33kΩ 3 3.3kΩ 6 1kΩ 1 10Ω
3 10kΩ horizontal trim pots (coded 103) (VR1-VR3)

The 2-way and 3-way pin headers can be mounted and soldered in place. The jumper plug can be installed in the keeper position. This position is just to store the jumper plug so that it is not lost. When placed in the keeper position, it does not make a connection for LK1.

There are two 1μF monolithic capacitors, mounted near REG1. These will be marked as '105' or '1μ' on their body. The 100nF capacitor just above S1 will be marked as '104' or '100n'.

The 433MHz transmitter module mounts parallel with the PC board by bending the mounting pins down at right angles. Make sure the pins are bent in the correct direction, so when installed, the module has the antenna pin toward the top edge of the PC board. The module sits about 3mm above the PC board.

Battery clips are mounted with the dimples pointing inward to face each other. The larger dimpled clip is for the + end and this mates well with a dint in the battery + terminal.

The antenna is made up using the straight wire link soldered in earlier and a spiral section, made using a 138mm length of 0.63mm enamelled copper wire. The insulation on each end is scraped clean for about 1mm to allow the ends to be soldered in position.

The wire is coiled by winding on about five turns on a 6.35mm (1/4-inch) former – a drill bit is ideal. The coil

winding should look something like our prototype (as shown in the photograph).

Before inserting the microcontroller, connect the battery and check that there is 5V between pins 5 and 14 on the IC1 socket. The voltage could range from 4.85V to 5.15V. Anything outside this means there is a problem. A 0V reading could mean the battery is in the wrong way, or there is a short circuit across the 5V supply rail.

If it is correct, remove the battery and insert IC1, the notch on the IC matching the notch on the socket.

The quiescent current can be measured if a 1kΩ resistor is placed in series with the battery to one of the clips. This is done by temporarily soldering one end of the resistor to the PC board at the + terminal. Connect your multimeter leads across the resistor and set the meter for reading millivolts. Then connect the '–' end of the battery to the minus terminal on the PC board and hold the unsoldered end of the resistor to the plus battery terminal. The voltage should be around 2.5mV to 3mV, representing 2.5μA to 3μA. The voltage will rise when one of the switches is pressed to about 3V, but fall back to the quiescent value after the LED has flashed and the switch is released.

Receiver construction

The receiver is constructed on a PC board, code 817, measuring 110mm × 141mm. This board is paired with the transmitter PCB and is available from the *EPE PCB Service*. It is housed in a 171mm × 121mm × 55mm IP65 sealed polycarbonate box with clear lid.

As you did with the transmitter, check the board fits neatly into its box. The corner mounting holes should be drilled out to accommodate M3 screws that are used to screw into the integral brass threads of the box. Holes for CON1 and CON2 are 2mm for the 4-way terminals and 4mm for the outside securing screws. The holes to secure the P-clamps are 4mm. Again, check the PC board for breaks in the copper tracks or for shorts between tracks, and repair any faults, if necessary.

Begin board assembly by installing the wire link and the resistors. It's a good idea to verify each resistor value with a digital multimeter before soldering it in position. PC stakes can go in next.

Install diodes D1 to D4 and Zener ZD1, taking care to orient correctly. The IC socket may now be installed, again making sure the notched end is correctly positioned. Switches S1 to S3 can be installed now, as well as the 3-way pin header for LK1. Install BCD1, ensuring the switch is oriented correctly, along with trimpots VR1 to VR3.

Transistors Q1 and Q2 are mounted with the orientation shown. Darlington transistor Q3 is not so immediately obvious: it is installed with its metal face towards LED3. Next, install the four capacitors – the three electrolytic (polarised) types need to be oriented as shown. CON1, CON2, CON3 and CON4 can be installed.

Because barrier terminal strips only come in four and six-way (and we need eight-way!) we made our own by carefully cutting off the mounting holes from one end of two four-way types and gluing them together. Because they are soldered to the PC board and there is also a mounting point at each end, this should be more than adequate.

Before soldering in, the combined CON1 and CON2 block is secured to the PC board using two M4 × 15mm screws placed through the two outside holes and with two M4 nuts on the underside of the PC board.

We ended up using only one of the clear protective coverings – it adequately covers the eight live terminals, while leaving the two mounting screws uncovered.

LED1 to LED5 are mounted about 15mm above the PC board, with red LEDs used for LEDs 1 to 3, while LED4 to LED5 are green. Be sure to orient each correctly. The UHF receiver module can be installed next; again take great care to position it correctly. The pin connections for the module are printed adjacent to each pin.

The three relays can be mounted now, followed by the 5V regulator. It mounts horizontal to the PC board on a small finned heatsink. The leads are bent down 90° to protrude through the holes in the PC board. Fasten the regulator and heatsink to the PC board (with an M3 × 10mm screw and nut), before soldering the leads in place underneath.

The antenna is made using 157mm of 1mm enamelled copper wire. The ends are stripped of enamel insulation for about 1mm using a sharp hobby knife to scrape it clean. Again, the wire is wound into a coil over a 6.35mm (1/4-inch) former such as a drill bit. The coil is stretched out to reach the two connection points and soldered in position.

That completes the construction of the boards themseleves. Next month, we'll look at testing and setting them up to 'talk' to each other and complete the project. We'll also look at some FAQs (frequently asked questions) about rolling code and code scrambling – stay tuned!

Table 1: Transmitter Identity Coding

IDENTITY	'8'	'4'	'2'	'1'
0	0V	0V	0V	0V
1	0V	0V	0V	5V
2	0V	0V	5V	0V
3	0V	0V	5V	5V
4	0V	5V	0V	0V
5	0V	5V	0V	5V
6	0V	5V	5V	0V
7	0V	5V	5V	5V
8	5V	0V	0V	0V
9	5V	0V	0V	5V
10 (or A)	5V	0V	5V	0V
11 (or B)	5V	0V	5V	5V
12 (or C)	5V	5V	0V	0V
13 (or D)	5V	5V	0V	5V
14 (or E)	5V	5V	5V	0V
15 (or F)	5V	5V	5V	5V

The default setting is Identity 0, as set by narrow PC tracks that connect the '8, 4, 2 and 1' inputs to 0V. Other Identities are set by breaking the appropriate track that connects an input to 0V and soldering a bridge from the input to the 5V rail. For example, to set Identity 1, break the 0V connection to the '1' terminal and solder to the 5V rail. For Identity 5, the '4' input would need to be tied to 5V, as well as the '1' input.

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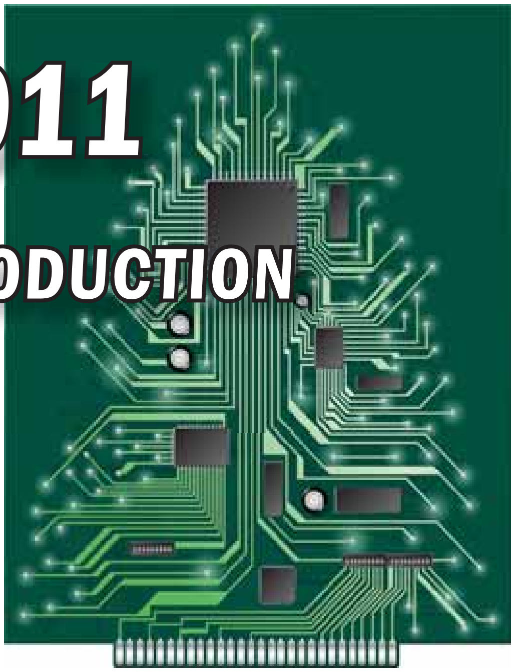
A BROAD-BASED INTRODUCTION TO ELECTRONICS



Part 10: Electronic circuit construction and testing

By Mike and Richard Tooley

Our Teach-In series aims to provide you with a broad-based introduction to electronics. We have attempted to provide coverage of three of the most important electronics units that are currently studied in many schools and colleges in the UK. These include Edexcel BTEC Level 2 awards as well as electronics units of the new Diploma in Engineering (also at Level 2). The series will also provide the more experienced reader with an opportunity to "brush up" on specific topics with which he or she may be less familiar.

Each part of our Teach-In series is organised under five main headings; Learn, Check, Build, Investigate and Amaze. Learn will teach you the theory, Check will help you to check your understanding, and Build will give you an opportunity to build and test simple electronic circuits. Investigate will provide you with a challenge which will allow you to further extend your learning and finally Amaze will show you the 'wow factor'!

THIS month, we look at the practical aspects of electronic circuit construction and testing. In ***Learn*** we introduce you to two of the most common and versatile items of test equipment, the *multimeter* and *oscilloscope*. ***Build*** looks at techniques that can be used to design, construct and test printed circuit boards (PCB) within Circuit Wizard.

Investigate involves taking measurements and fault finding on a simple voltage regulator circuit. Finally, ***Amaze*** looks at the reliability of electronic components.

Learn

At BTEC Level 1 and Level 2 you need to be able to make measurements on simple DC and AC circuits including:

- Measuring *voltage*, *current* and *resistance* using a multi-range meter (or *multimeter*)
- Displaying waveforms and making measurements of voltage (peak and peak-to-peak) and time using an *oscilloscope*.

Fig.10.1. Multimeters can be either analogue (left) or digital (right)

In all cases, you will need to ensure that you work safely and observe correct procedures (for example, switching off and disconnecting the power supply *before* connecting test leads). We begin this month's ***Learn*** by introducing the test instruments that you will be using.

Multimeters

One of the most common, versatile and easy-to-use instruments is the multi-range meter, or multimeter. This instrument combines the functions of a voltmeter, ammeter and ohmmeter into a single instrument. Many multimeters also have additional ranges, for example to check continuity, measure capacitance or to check diodes and transistors.

Most multimeters operate from internal batteries, and are thus independent of the mains supply. This allows you to easily carry them around and make measurements on electronic equipment when you are away from the laboratory or workshop.

There are two main types of multimeter: *analogue* and *digital* (see Fig.10.1). Analogue multimeters employ conventional moving coil movements; the display takes the form of a pointer moving across a calibrated scale.

This arrangement is not so convenient to use as that employed in digital instruments because the position of the pointer is rarely exact and may require interpolation. Analogue instruments do, however, offer some advantages, not least, is that it's very easy to make adjustments to a circuit, while observing the relative direction of the pointer; a movement in one direction representing an increase and in the other a decrease.

Despite this, the main disadvantage of analogue meters is the rather cramped and sometimes confusing scale calibration. To determine the exact reading requires first an estimation of the pointer's position, and then the application of some mental arithmetic based on the range switch setting (see Fig.10.2)

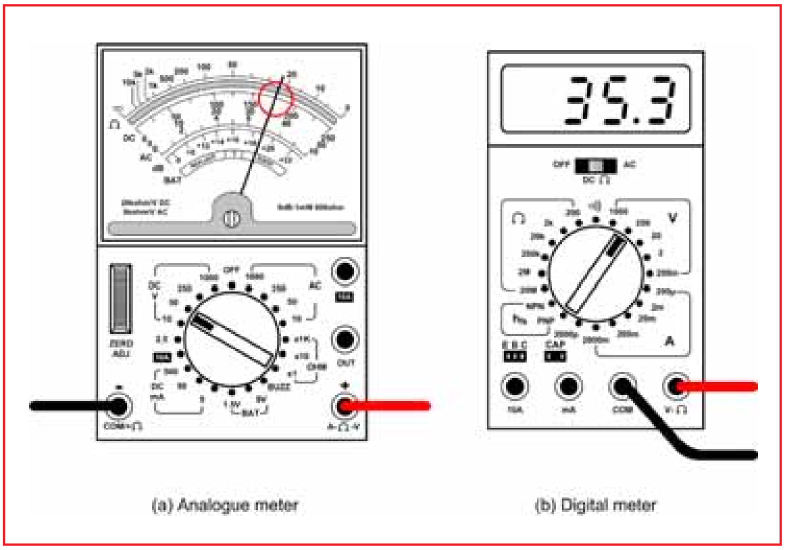


Fig.10.2. A comparison of the displays provided on analogue and digital multimeters. Both meters indicate the same value.

Unlike their analogue counterparts, digital multimeters are usually extremely easy to read and have displays that are clear, unambiguous, and capable of providing a very high resolution. It is also possible to distinguish between readings that are very close. This is just not possible with an analogue instrument.

Digital multimeters offer a number of significant advantages; when compared with their analogue counterparts. The display fitted to a digital multimeter usually consists of a 3½-digit seven-segment display—the ½ simply indicates that the first digit is either blank (zero) or 1.

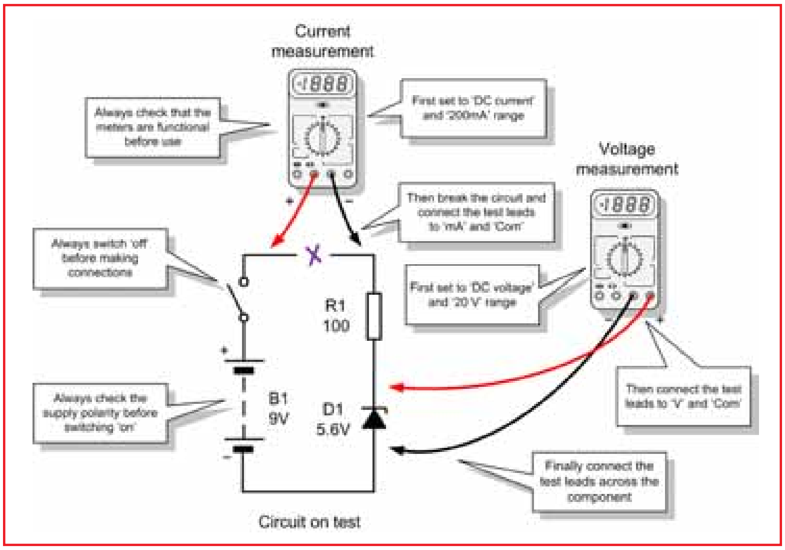


Fig.10.3. The procedure for making current and voltage measurements using a digital multimeter

Consequently, the maximum indication on the 2V range will be 1.999V. This suggests that the instrument is capable of offering a resolution of 1mV on the 2V range (in other words, the smallest increment in voltage that can be measured is 1mV).

Depending on the size and calibration markings on the instrument's scale, the resolution obtained from a comparable analogue meter would typically be about 50mV, and so the digital instrument provides us with a resolution that is many times greater than its analogue counterpart.

Multimeter measurements

The procedure for making current and voltage measurements using a digital multimeter, is shown in Fig.10.3. We've chosen this type of instrument for our example because you will probably be using a modern digital instrument rather than an older analogue type.

Note how it is necessary to break the circuit and insert the meter when making a current measurement. Notice also how the voltmeter is connected in parallel with the circuit at the point at which you are making a measurement.

It is *essential* that you get these two connections right and that you select the correct ranges on the multimeter. Failure to observe these two simple precautions can result in damage to the meter and/or the circuit under test!

In Fig. 10.3, one of the meters is used to measure the supply current (note that the circuit must be broken and the meter inserted into it), while the second instrument is being used to measure the potential difference (voltage drop) across diode D1.

The initial range settings (200mA for the current measurement, and 20V for the voltage measurement) are chosen so that they are both greater than those that we would expect to find in the circuit. For example, we would calculate the current flowing in the circuit to be (9 – 5.6)/100 amps or 34mA.

Similarly, we could assume that the voltage that we would measure should be 5.6V (the same as the Zener voltage), but in no event would we expect it to be greater than the supply voltage (9V). We have, therefore, left quite a margin for safety with the two ranges that we've selected!

Please note!

It is *essential* to switch off and disconnect the power supply *before* attempting to connect test leads. When the meter ranges have been set and the connections made, the supply can be reinstated and switched back on, so that measurements can be made.

Please note!

In your school/college course you will only be working with equipment that uses safe low voltage supplies. Even so, it is essential to observe Health and Safety precautions whenever you are working on live electrical and electronic circuits.

When in doubt, you should always refer to your tutor!

Please note!

When the circuit on test uses large value capacitors it may be necessary to wait a few minutes in order to allow them to discharge safely before making connections to the circuit.

Please note!

Make sure that you only use properly *insulated* test leads to make connections to a circuit on test. The leads should be fitted with clips and probes to make connections to a circuit.

Never use bare wires and test prods as these can cause short-circuits to adjacent connections!

Oscilloscopes

Oscilloscopes can be used in a variety of measuring applications, the most important of which is the display of time related voltage waveforms.

Older oscilloscopes (Fig.10.4) used cathode ray tubes (CRT) for their displays. In order to make accurate measurements, the face of the CRT was fitted with a *graticule* that was either integral with the tube or took the form of a separate translucent sheet. Modern oscilloscopes use flat LCD displays, either colour or monochrome, which incorporate an electronically generated measuring scale. Accurate voltage and time measurements are made with reference to the scale or graticule, applying a scale factor derived from the appropriate range switch.

The use of the graticule is illustrated by the following example. An oscilloscope screen is depicted in Fig.10.5. This diagram is reproduced at a reduced size. If shown full-size, the gratical markings would be spaced at 1cm and the fine graticule markings would be every 2mm along the central vertical and horizontal axes.

The oscilloscope is operated with all relevant controls in the 'CAL' position. The timebase (horizontal deflection) is switched to the 1ms/cm

Fig.10.4. A typical two-channel general purpose oscilloscope that uses a CRT display

range and the vertical attenuator (vertical deflection) is switched to the 1V/cm range.

The overall height of the trace is 4cm, and thus the peak-to-peak voltage is 4 × 1V = 4V. Similarly, the time for one complete cycle (period) is 2.5 × 1ms = 2.5ms.

One further important piece of information is the shape of the waveform that, in this case, is sinusoidal. The function of some of the more common controls and adjustments for a general purpose oscilloscope are listed in Table 10.1.

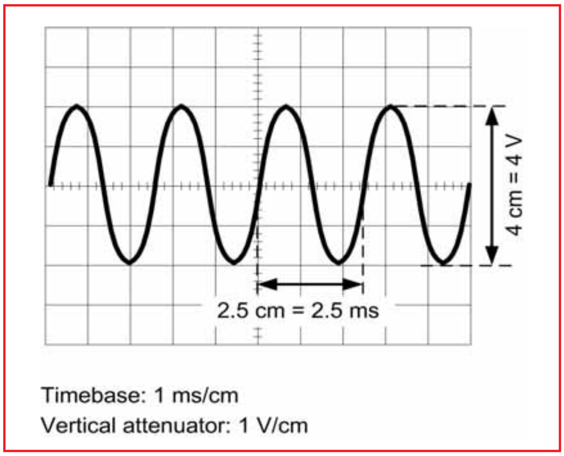


Fig.10.5. Using an oscilloscope scale

Please note!

Before taking meaningful measurements from a CRT screen it is absolutely essential to ensure that the front panel variable controls are set in the *calibrate* (CAL) position. Results will almost certainly be inaccurate if this is not the case!

Oscilloscope measurements

A typical oscilloscope measurement is shown in Fig.10.6. In this application the oscilloscope is being used to display the waveforms in a simple half-wave rectifier power supply.

As with the multimeter measurements that we met earlier it is essential to make initial adjustments to the oscilloscope BEFORE connecting the oscilloscope to the circuit and switching on the supply. Once again, when in doubt, you should refer to your tutor!

Virtual instruments

In recent years, a new type of electronic measuring instrument has become available. Rather than using conventional analogue, digital or CRT displays, these *virtual instruments* use plug-in adapters or USB-connected interfaces, together with a PC (either desktop or laptop). The interface circuit captures a digital sample of the analogue input, which can then be stored in memory and recalled for later display.

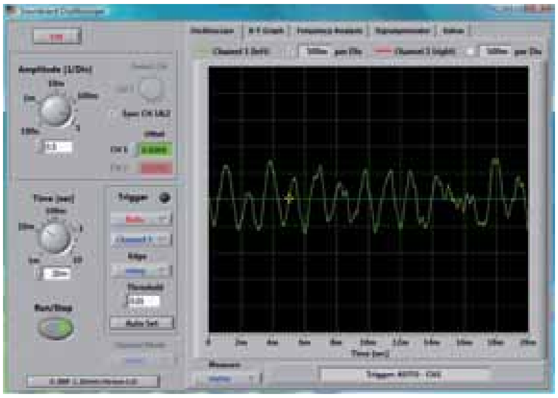


Fig.10.7. A typical display produced by a PC-based virtual oscilloscope

Virtual instruments offer a number of advantages when compared with conventional test instruments, including the ability to display waveform parameters (such as time, voltage, frequency and phase) as well as being able to store, recall and print waveform data. A typical virtual soundcard oscilloscope display is shown in Fig.10.7.

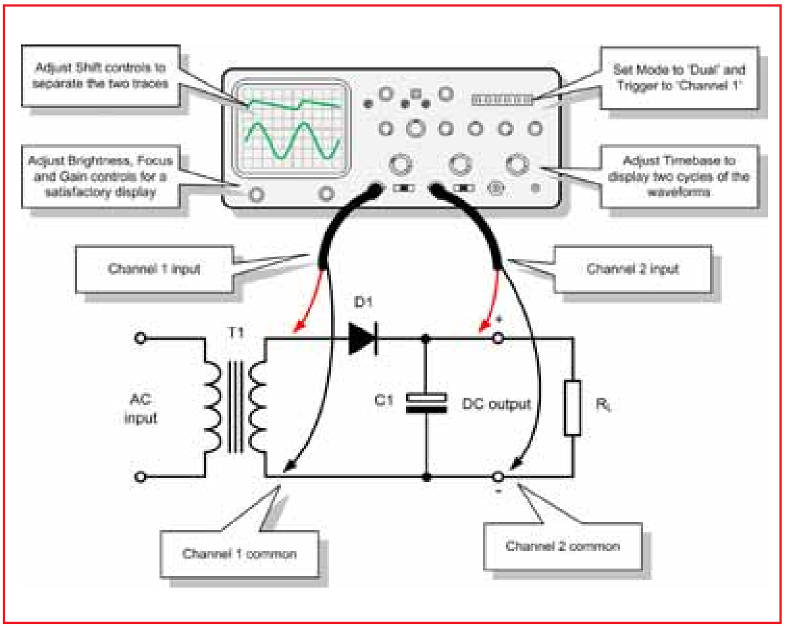


Fig.10.6. Oscilloscope measurements on a simple half-wave rectifier power supply

Table 10.1. Oscilloscope controls and adjustments

Control	***Adjustment***
Focus	Provides a correctly focused display on the screen
Intensity	Adjusts the brightness of the display
Astigmatism	Provides a uniformly defined display over the entire screen area and in both x and y directions. The control is normally used in conjunction with the focus and intensity controls
Trace rotation	Permits accurate alignment of the display with respect to the graticule (CRT displays only)
Scale illumination	Controls the brightness of the graticule or scale
Horizontal deflection system	
Timebase (time/cm)	Adjusts the timebase range and sets the horizontal time scale. Usually this control takes the form of a multi-position rotary switch and an additional continuously variable control is often provided. The 'CAL' position is usually at one, or other, extreme setting of this control
Stability	Adjusts the timebase so that a stable waveform display is obtained
Trigger level	Selects the particular level on the triggering signal at which the timebase sweep commences
Trigger slope	This usually takes the form of a switch that determines whether triggering occurs on the positive or negative going edge of the triggering signal
Trigger source	This switch allows selection of one of several waveforms for use as the timebase trigger. The options usually include an internal signal derived from the vertical amplifier, a 50Hz signal derived from the supply mains, and a signal which may be applied to an External Trigger input
Horizontal position	Positions the display along the horizontal axis (CRT displays only)
Vertical deflection system	
Vertical attenuator (V/cm)	Adjusts the magnitude of the signal attenuator (V/cm) and sets the vertical voltage scale. This control is invariably a multi-position rotary switch; however, an additional variable gain control is sometimes also provided. Often this control is concentric with the main control and the 'CAL' position is usually at one, or other, extreme setting of the control
Vertical position	Positions the display along the vertical axis of the display
AC-DC-ground	Normally an oscilloscope employs DC coupling throughout the vertical amplifier; hence a shift along the vertical axis will occur whenever a direct voltage is present at the input. When investigating waveforms in a circuit, one often encounters AC superimposed on DC levels; the latter may be removed by inserting a capacitor in series with the signal. With the AC-DC-ground switch in the AC position, a capacitor is inserted in the input lead, whereas in the DC position the capacitor is shorted. If ground is selected, the vertical input is taken to common (0V) and the oscilloscope input is left floating. This last facility is useful in allowing the accurate positioning of the vertical position control along the central axis. The switch may then be set to DC and the magnitude of any DC level present at the input may be easily measured by examining the shift along the vertical axis.
Chopped-alternate	This control, which is only used in dual-beam CRT oscilloscopes, provides selection of the beam splitting mode. In the chopped position, the trace displays a small portion of one vertical channel waveform followed by an equally small portion of the other. The traces are, in effect, sampled at a relatively fast rate, the result being two apparently continuous displays. In the alternate position, a complete horizontal sweep is devoted to each channel alternately.

Check – How do you think you are doing?

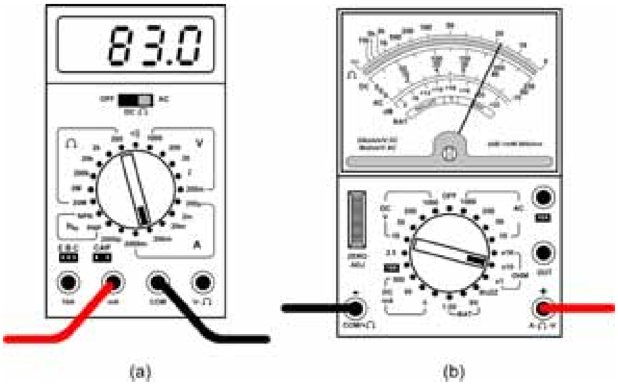


Fig.10.8. See Question 10.2

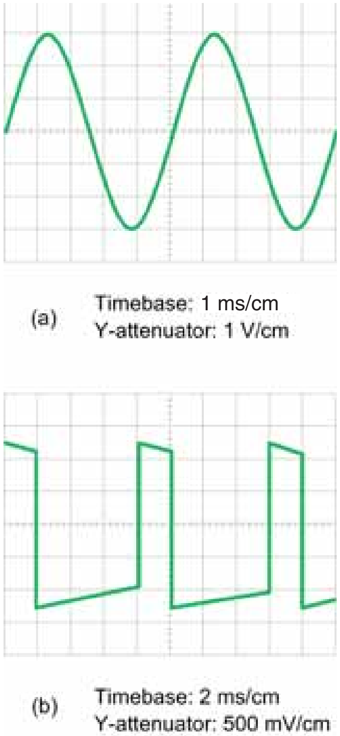


Fig.10.9. See Question 10.3

10.1. Briefly explain the difference between analogue and digital multimeters. Which type of instrument offers the greatest resolution? Why is this?

10.2. What indications are displayed on the analogue and digital multimeters shown in Fig.10.8?

10.3. What information (eg, amplitude, period) can be obtained from the oscilloscope displays shown in Fig.10.9?

10.4. Explain the function of each of the following oscilloscope controls:
(a) Brightness
(b) Focus
(c) Stability
(d) Trigger source
(e) Vertical attenuator.

10.5. Explain why it is important to ensure that the variable controls of an oscilloscope are placed in the 'CAL' position before attempting to make an accurate measurement.

10.6. What adjustment should be made to an oscilloscope when it is to be used to display a small AC voltage superimposed on a much large DC voltage? Explain why this adjustment is necessary.

For more information, links and other resources please check out our Teach-In website at:
www.tooley.co.uk/teach-in

Build – The Circuit Wizard way

A soft touch

IN previous instalments of ***Build***, we've been using Circuit Wizard to simulate and test various circuits in order to demonstrate electronic theory. However, in this edition, we are going to look at the process of taking an electronic circuit and converting it to a printed circuit board (PCB) design that can be produced for real.

This is one of the real gems of the Circuit Wizard software as you'll see later on. We will try out some of the software's automatic conversion tools, as well as investigating some of the more advanced functionality. Once you've completed this tutorial you should be ready to enter, test and convert your own circuits to a PCB design.

The electronics industry is heavily reliant on software throughout the *product design* cycle. An example design cycle for an electronic circuit is shown in Fig.10.10.

A designer might use various tools and calculators to design the initial circuit. The circuit would then be drawn in an electronic format in a process known as *schematic capture*.

The circuit may then be simulated and analysed using a Simulation Program with Integrated Circuit Emphasis (SPICE). SPICE software runs thousands of calculations on each junction point or node of a circuit, taking into account all of the components.

There are various types of analysis that can be carried out: information can be displayed in real time (as in Circuit Wizard) to show a virtual simulation, or gathered and presented in reports or graphs/charts to show how a circuit functions over time and/or with varying characteristics.

In this way a designer can be pretty sure that a circuit will operate correctly before spending time and money producing the physical board. Once the operation is confirmed, the information from the circuit is then used to generate a PCB design ready for production and testing of the circuit.

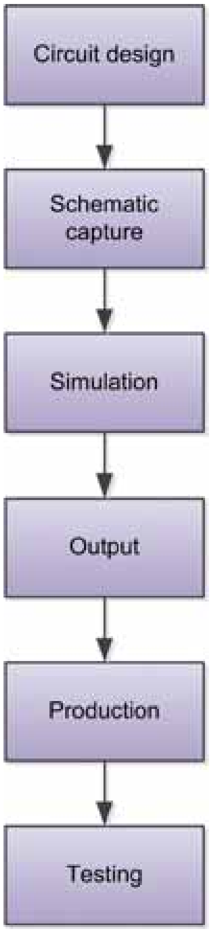


Fig.10.10. A typical design flow for an electronic circuit

On the board

So, let's get to work and see Circuit Wizard in action generating a PCB! Start off by entering the circuit shown in Fig.10.11; a basic potential divider-based automatic light circuit. Ensure that you get all of the component values and connections correct.

Once you've entered the circuit, run a quick simulation to make sure that it functions correctly. Press the 'Run' button on the toolbar and raise/lower the light level on the LDR (R2) to ensure that the LED (D1) lights under low light conditions).

Now we're ready to begin the conversion process. Click on the 'Convert to PCB Layout' button on the toolbar (Fig.10.12), or alternatively use the menu to navigate through 'Project', 'Circuit Symbols' then 'Convert to PCB Layout…'. This will start a short wizard to guide you through the conversion process.

Click 'Next' to continue to the next screen, where you will be asked to select a board type (single or double-sided) and a track size. For most home/school low voltage DC projects, with a relatively low component count and where space and component density is not a premium, we would suggest normal tracks on a single-sided board.

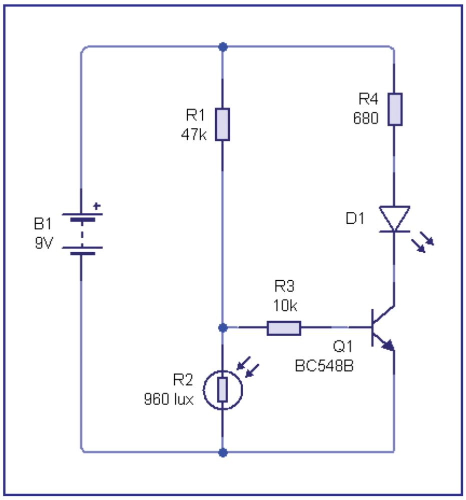


Fig.10.11. A simple light-operated switch circuit ready for conversion to a PCB layout

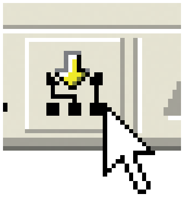
Therefore, select ‘Single-Sided; Normal Tracks’ and then click on ‘Next’. The next screen allows us to change the size and shape of the board. In this case, we’ll leave these as the default and click on ‘Next’.

Last, on the final page, select ‘Convert’ and keep your fingers crossed! As Circuit Wizard carries out the conversion of your circuit to a PCB, it will animate the placing of the components, followed by the calculation of the optimum track layout. If all goes well, after a short period of time you should receive a completion message detailing the success of your conversion (Fig.10.13). Closing this should reveal your new PCB layout!

Fig.10.14 shows our example PCB layout; this may vary slightly from yours. It should be noted that the automatic routing functionality of Circuit Wizard is a little limited, and it does struggle to route much more than the simplest circuits without a little help. However, we’ll be looking at tactics for creating more complex PCBs later in this article.

Now that we have created our PCB layout, there are a number of exciting things that we can do with it. A superb feature of Circuit Wizard is that as well as simulating the circuit schematic, you can also simulate a virtual copy of your PCB design.

As with a real circuit, we must first attach a suitable power supply. Drag and drop across a PP3 9V battery from the Off-board Components in the Component Gallery (Fig.10.15).



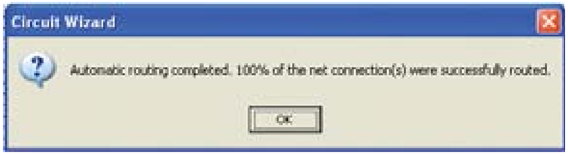


Fig.10.13. Automatic routing confirmation

Fig.10.12 (above left). The ‘Convert to PCB layout’ toolbar button

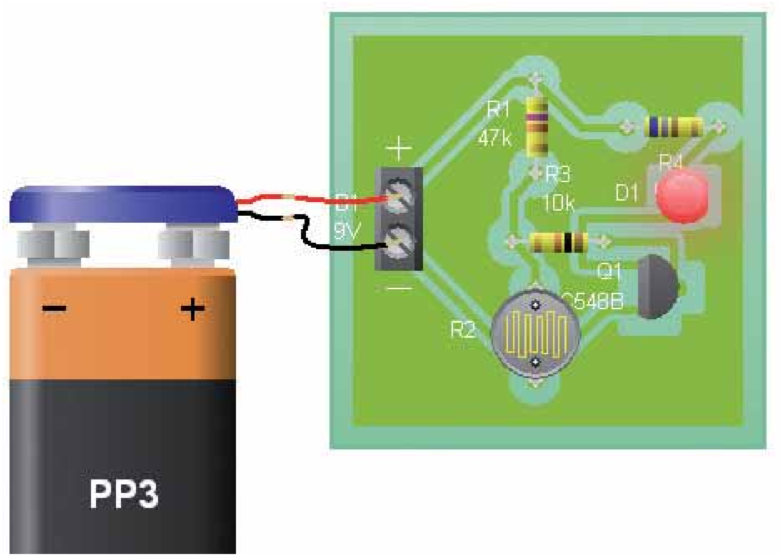


Fig.10.14. Example PCB layout for the simple light-operated switch circuit in Fig.10.11, and wiring the PP3 9V battery to the PCB

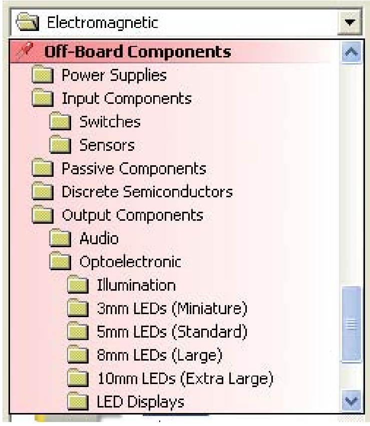


Fig.10.15. Off-board Components in the Component Gallery

Make sure that you select the Off-board Component variant, *not* a PCB Component. Wire the PP3 battery’s positive and negative connections to the two-pin screw terminal block by dragging from the ends of the battery connector wires (Fig.10.14).

Virtual test

You are now ready to virtually test your PCB; start the simulation using the ‘Run’ button on the toolbar, as you would for a standard circuit, and try out the function of the circuit by changing the light level on the LDR. On the left-hand side of the screen you may select various different views of the PCB. The default is ‘Real World’, which shows a full colour representation of what the board will actually look like when constructed. ‘Normal’ is a more traditional PCB design view. As with schematic simulation, the PCB may also be simulated in a ‘Current Flow’ and ‘Logic Level’ view.

In ‘Current Flow’ view, the tracks are colour coded depending on the instantaneous voltage and ‘marching ants’ demonstrate the rate of flow of current (Fig. 10.16). This is particularly useful for understanding the operation of the circuit, as well

Build – The Circuit Wizard way

as providing a comparison for fault finding/testing of the completed circuit. Try simulating the circuit in this mode.

The 'Logic Level' view is excellent when dealing with digital circuits, as it highlights the logic state of pins and tracks. 'Artwork' shows the output PCB mask and 'Unpopulated' shows the physical board along with the silk screen layer, which can be very useful as a constructional aid.

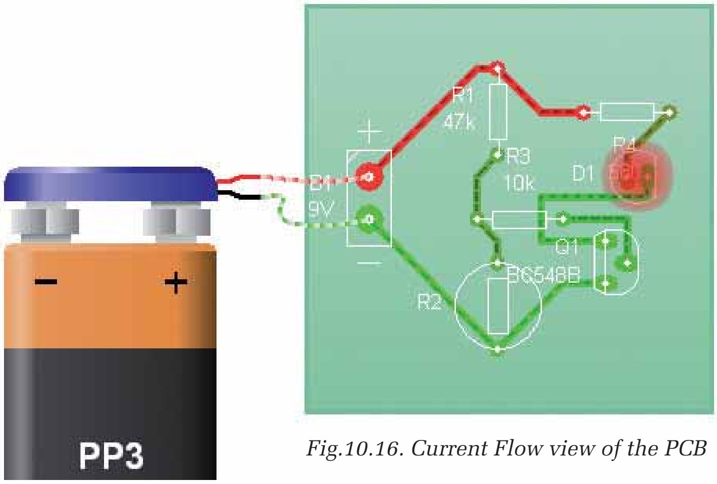


Fig.10.16. Current Flow view of the PCB

Design output

How you now output your design ready for production will depend on your chosen circuit board production method. The print menu (Fig.10.17) allows you to print various artwork, including top and bottom copper layers, silk screen as well as mirrored and inverted designs.

For those using standard UV photo-resist board and a traditional etching technique, 'Solder Side (Bottom) Artwork' would be printed using a laser printer on to acetate ready for UV exposure. If you use isolation gap routing or sending your data away to a third party for production, then the CAD/CAM menu (Fig.10.18) permits you to output the PCB data in DXF, NC and Gerber formats. Schools with Techsoft CAM equipment may copy the PCB data and paste it into Techsoft 2D PCB ready for CNC routing and drilling.

More complex circuits

As you've seen, Circuit Wizard does a nice job of automatically converting a simple circuit into PCB with no help from the user. However, with a more complex circuit you may need to make a few tweaks and get a bit more involved in the generation process. To demonstrate this, we will convert a slightly more complex circuit; this time a 555 astable mode LED flasher circuit. Enter the circuit shown in Fig.10.19, and verify its operation through simulation.

Follow through the PCB conversion process as you did for the first

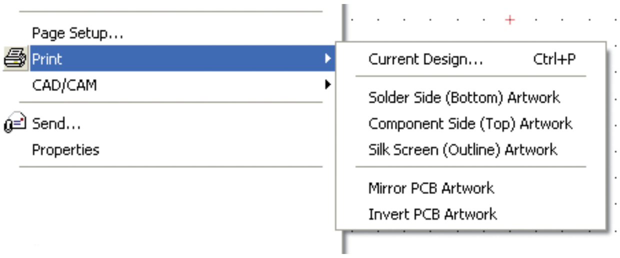


Fig.10.17. The Circuit Wizard PCB print menu

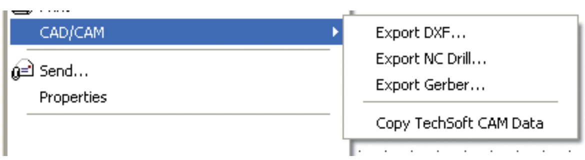


Fig.10.18. Circuit Wizard's CAD/CAM menu

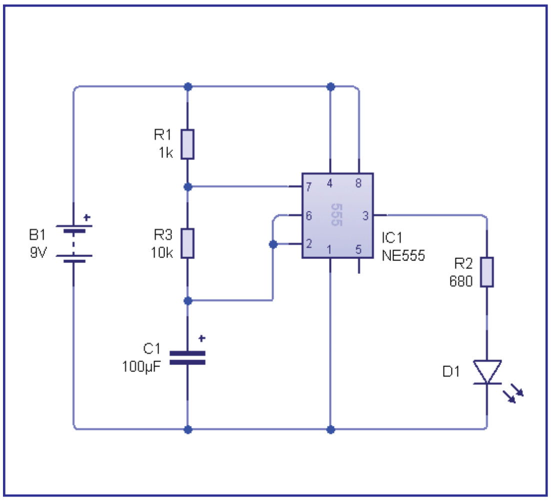


Fig.10.19. 555 astable mode LED flasher

circuit. Once complete, you may find that you receive a routing message similar to that shown in Fig.10.20, explaining that the software was unable to completely convert your circuit automatically.

In our example, you can see that only 92% of the connections could be made. It is important to note that you may be more or less successful than our example circuit, depending on how you have drawn your circuit and your software setup.

The description here is indicative of how to deal with a PCB that fails to completely route using the automatic routing feature. Inspecting the generated design (Fig.10.21), you can see that the software inserted a jumper and one connection could not be made at all (shown by a thin green line).

Note, this does not mean to say that it is impossible to wire the circuit, just that the software was unable to do so automatically and/or using the current configuration. Fortunately, we can step in here to make the job of the software a little easier.

Rats nest

Return to your circuit diagram and repeat the conversion process.

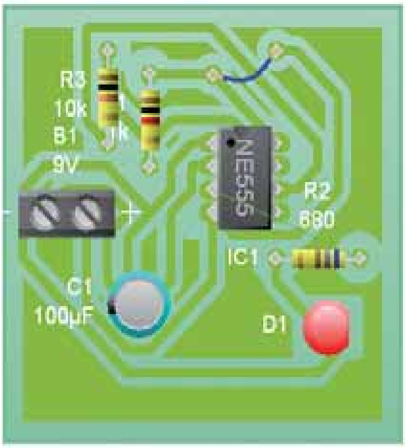


Fig.10.21. The generated PCB layout showing incomplete routing

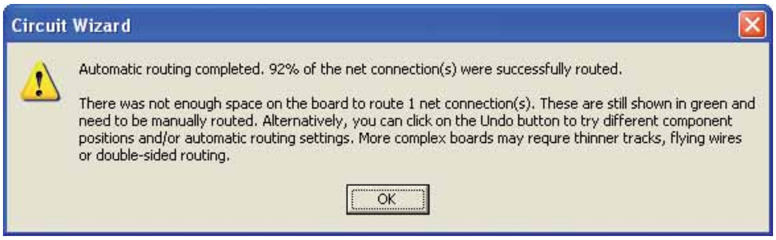


Fig.10.20. Automatic routing message for the circuit of Fig.10.19

However, this time select 'Rats Nest; No Placement or Routing' on the second screen of the wizard. You should then be presented with a blank PCB board and a set of the required components, as shown in Fig.10.22.

The pins of the components are linked by green lines showing where the connections are required. This mass of criss-crossing wires is often referred to as a 'rats nest'.

We now have to place the components on to the PCB. Rather than simply placing components at random, what we are looking to do here is to place the components so that they can be routed with tracks in the easiest and most efficient manner. We might also require components in specific locations; for example an off-board connector at the side of the PCB, or the fixed location of an LED so that it locates in the right place on a finished product.

To achieve the former, it is essentially a case of placing the components so that there are as few cross-overs of green lines as possible. Hence, this will make the job of routing the tracks as easy as possible and avoid the requirement of jumpers/

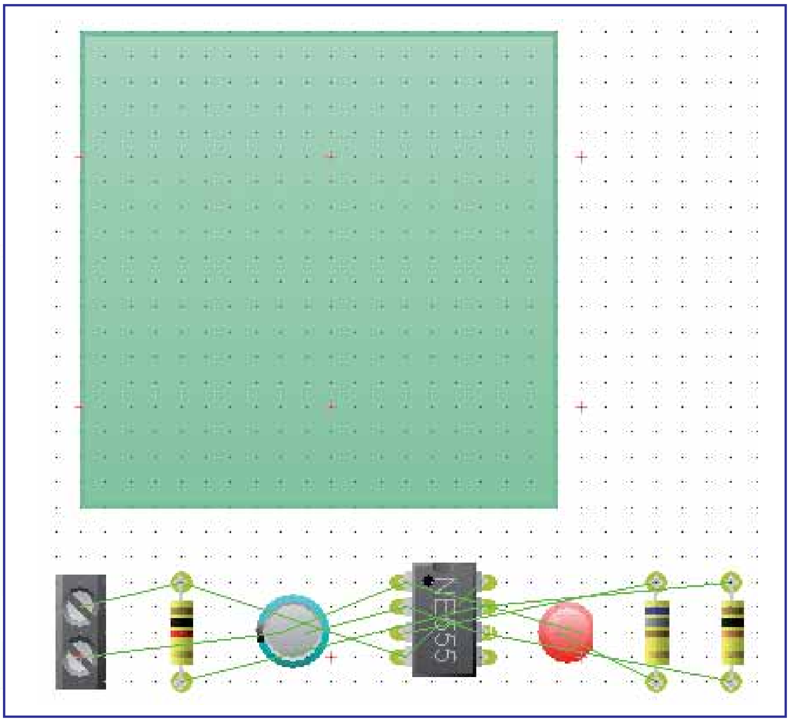


Fig.10.22. Starting point for the 'rats nest' PCB layout

Build – The Circuit Wizard way

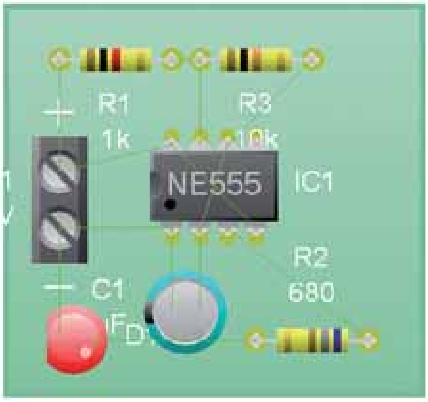


Fig.10.23. Improved layout using 'rats nest' technique

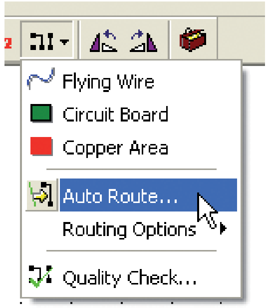


Fig.10.24. Selecting automatic routing from the PCB Layout Tools menu

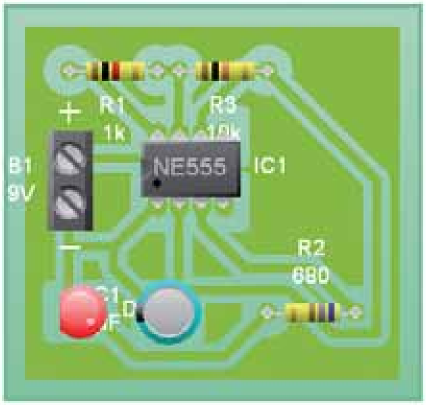


Fig.10.25. The completed auto-routed layout

links. As well as component position, their orientation may be altered by rotation (keyboard shortcut CTRL+R).

Notice that as you move components to a new location, the green lines will update to the nearest common point for that net. This allows you to significantly simplify the rats nest prior to routing the tracks. Fig.10.23 shows an example layout which places the battery connector at the edge of the board and attempts to leave the rats nest as clean as possible.

On track

At this point we can either start to draw our tracks manually in-line with the green nets, or instruct Circuit Wizard to attempt to automatically route the board now that we have prepared the component layout more efficiently. The author's personal preference is to have the software route the tracks automatically, then go in and modify the results as required to achieve a nice neat job. However, it's up to the individual user to experiment and decide upon their favoured approach.

To initiate automatic routing, click on the 'PCB Layout Tools' icon from the toolbar and select 'Auto Route…' (Fig.10.24). Our completed auto routed layout looks as shown in Fig. 10.25. The layout is now complete and ready for virtual simulation and output for production.

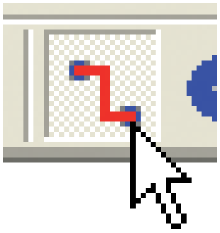


Fig.10.26. The track button

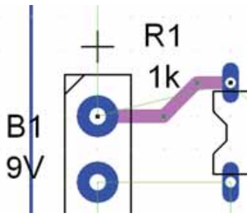


Fig.10.27. A manually added PCB track

If you prefer to draw the tracks manually (or indeed if Circuit Wizard fails to route your circuit automatically) select the track button from the toolbar (Fig.10.26). Tracks are started by left-clicking with additional segments added by further left-clicking and are finished by right-clicking.

Previous users of PCB drafting software will find the track drawing process familiar, whereas first-time users may find it takes a little practice for it to become intuitive. You may find it easier to use 'Normal' view for manual track drawing. Fig.10.27 shows a track manually added to the 555 circuit.

Configuration options

A number of additional PCB conversion configuration options are available through the PCB wizard. On the second screen, tick 'Allow me to customise the PCB layout conversion'. You will then be provided with many additional options as you proceed through the conversion process.

One of these additional configurations is the ability to alter the physical component mappings. When converting to a PCB, Circuit Wizard selects the most appropriate PCB component footprint based on the component variant and values selected.

However, there may be times when you wish to specify a different model from that chosen by default. The screen shown in Fig.10.28 will be included in the wizard when the tick box is checked as described earlier, allowing you to alter the package

used for each component (in this case showing the package selection window for the battery, B1).

On the subsequent wizard screen you are given a number of component placement options. An interesting option is 'Take into account component positions'. When Circuit Wizard converts to a PCB it tries to order the components as you have set them out on your schematic.

This may be convenient for keeping component numbering sequential. However, in practice this is not always the best way to place components for efficient routing.

If you find your circuits are not automatically routing and/or the components are being placed in a poor manner, try unticking this option. This can have a dramatic effect on the results.

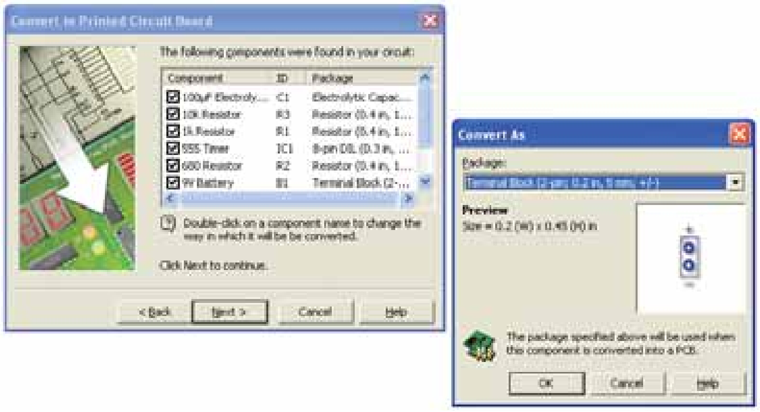
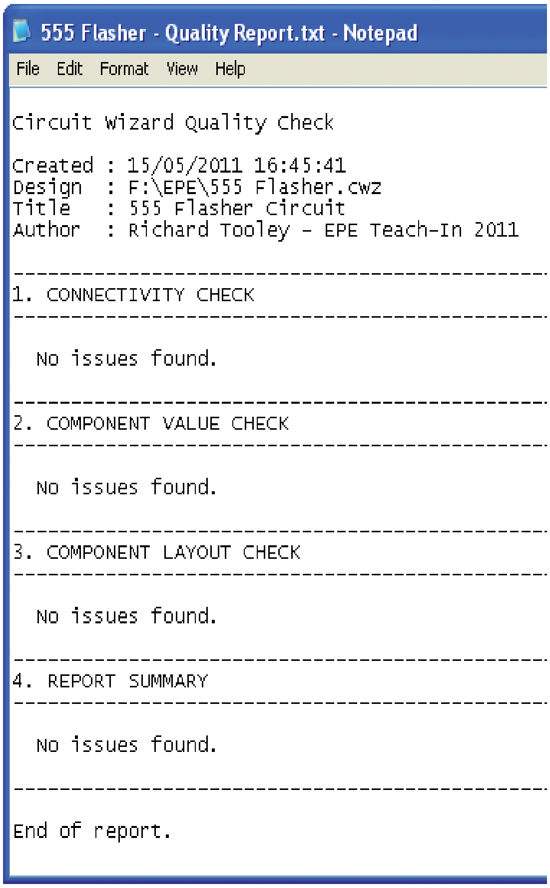


Fig.10.28. Specifying different component models

Finally, one really useful tool is Quality Check. This may be accessed from the PCB Layout Tools icon on the toolbar, or by selecting 'Project', 'PCB Components' then 'Quality Check' from the menu.

This will analyse the PCB layout in comparison to your circuit diagram, to ensure that all of the connections have been made correctly, as well as various other checks. This is particularly useful when routing manually to check the connectivity of your design. Fig.10.29 shows an example Quality Check Report.



555 Flasher - Quality Report.txt - Notepad

File Edit Format View Help

```
Circuit Wizard Quality Check

Created : 15/05/2011 16:45:41
Design  : F:\EPE\555 Flasher.cwz
Title   : 555 Flasher Circuit
Author  : Richard Tooley - EPE Teach-In 2011

----------------------------------------------
1. CONNECTIVITY CHECK
----------------------------------------------

  No issues found.

----------------------------------------------
2. COMPONENT VALUE CHECK
----------------------------------------------

  No issues found.

----------------------------------------------
3. COMPONENT LAYOUT CHECK
----------------------------------------------

  No issues found.

----------------------------------------------
4. REPORT SUMMARY
----------------------------------------------

  No issues found.

----------------------------------------------

End of report.
```

Fig.10.29. An example of a Quality Check Report

We've really only scratched the surface of the PCB conversion and drafting tools within Circuit Wizard. As with any software tool, the best way to learn more is to get 'hands on' and use the software.

In the next edition of ***Build*** we'll be giving you the opportunity to do just that with a range of project circuits for you to enter, test, convert and build using all of the skills you've learnt throughout the series.

Answers to Check questions

10.1 See page 43 and page 44

10.2 (a) 83.0mA AC

(b) 180Ω

10.3 (a) Sine wave; 5ms period (frequency = 200Hz); amplitude 6V pk-pk

(b) Pulse wave; 8ms period (p.r.f. = 125Hz; high time = 2ms, low time 6ms; 25% duty cycle (mark-to-space ratio = 1:3; (amplitude 2.5V pk-to-pk

10.4 See page 46 and Table 10.1

10.5 See page 45 and Table 10.1

10.6 See page 46 and Table 10.1

Investigate

Fig. 10.30 shows a simple regulated power supply and three common items of test equipment.

1. Photocopy the diagram and add connecting wires to the diagram in order to show:

(a) How the collector current of transistor TR1 is measured

(b) How the base-emitter voltage of TR1 is measured.

2. For (a) and (b) above, list the initial adjustments that should be made to the test equipment.

3. If the output voltage of the circuit is measured at 0V and the input voltage as 15.1V, what measurements would you make, and in what order, to locate the fault? Explain your answer.

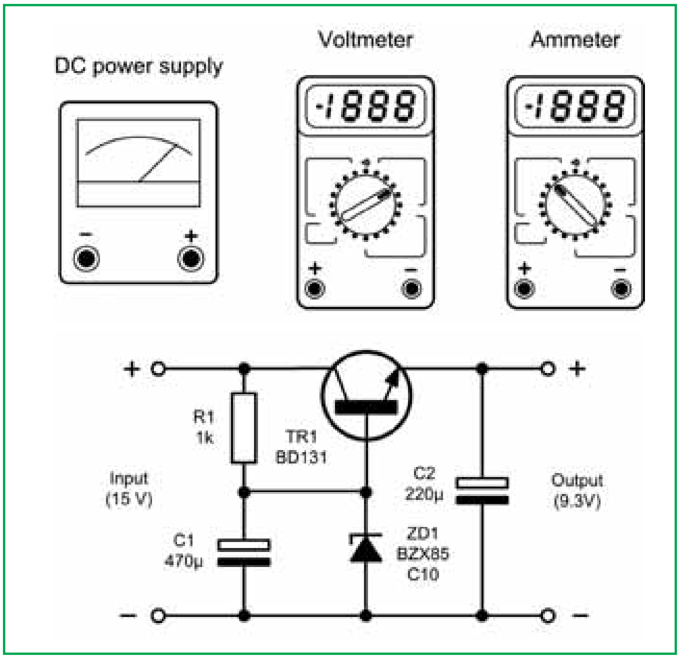


Fig.10.30. See Investigate

Amaze

In our everyday lives we are increasingly reliant on highly complex electronic systems that involve large numbers of individual component parts. However, because each individual part can be prone to failure, we need to ensure that each component has a very high reliability in order to ensure that the equipment as a whole remains free from failure. Reliability (ie, the ability to operate without failure) is thus a paramount consideration for those involved with the design of electronic equipment.

To put this into context: suppose that we know that one out of every 100000 of a particular component type is likely to break down every hour. This implies that an item of equipment that makes use of 100 of these components would break down at an average interval of 1000 hours or less than 42 days operation. In many cases this would be woefully inadequate!

The requirement for a very high degree of reliability is crucial in many applications. In satellite communications, the electronics is often expected to operate for at least 20 years without failure, simply because it would be impossible to recover and repair the satellite without spending far more than the satellite was actually worth. Added to this, there would be considerable loss of revenue while the satellite was out of service: in many cases this might amount to millions of pounds or dollars.

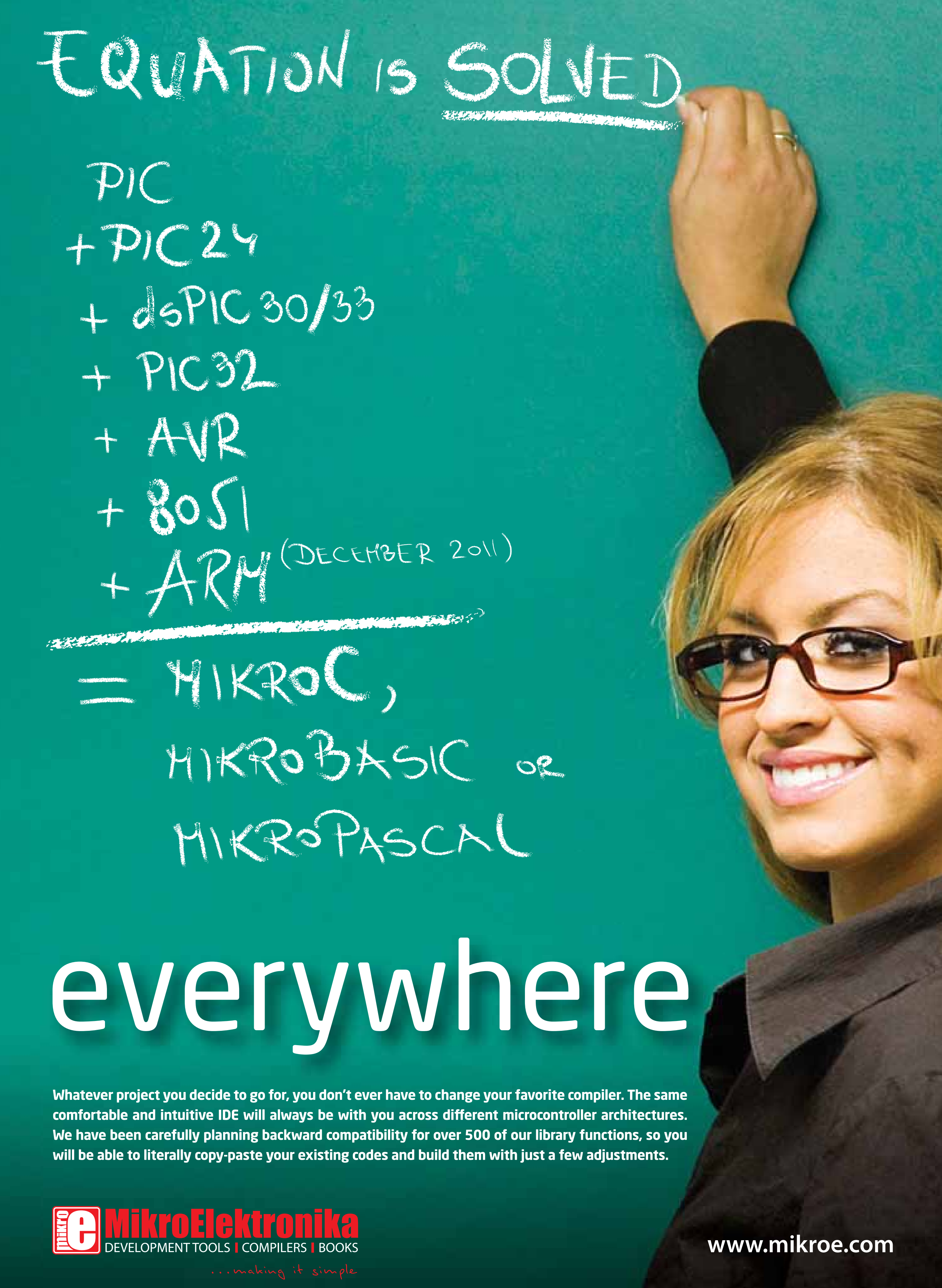
The failure rate of individual components depends on the situation and environment in which they are used. A satellite experiences extreme forces and temperatures during launch and manoeuvre into final orbit.

In consequence, the environment in which a satellite operates is considered severe when compared with that in which most consumer electronic equipment finds itself. For this reason, we need to ensure that only the most reliable types of electronic component are used in satellites.

But just how reliable are the electronic components used in the circuits that you construct? A single low-cost metal oxide resistor operated within its rating and in a benign environment can be expected to a have working life of more than 1000 years. The same item fitted into a satellite would need to have a reliability that is at least ten times and preferably more than 100 times greater than this!

Next month!

In next month's *Teach-In 2011* we round up the series with a brief look back at previous parts. We shall also be including some fun revision activities as well as essential reference information. Our series concludes with a selection of electronic projects that you can build and test using Circuit Wizard.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PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

MPLAB-X

THIS month, we take a break from our Internet Computer series to look at a major new development from Microchip, the MPLAB-X Integrated Development Environment, or IDE.

The MPLAB IDE (and IDEs in general) provides a framework for an editor, compiler, programmer, debugger and other tools to work together. Build your project with the compiler in one window, and when it reports an error you can click on the message to be taken to the source file and offending line of code. It helps make software development a faster, more pleasant activity. While not everyone likes the integrated approach (preferring instead separate command windows, and batch file-based build scripts) it is undeniably a more efficient method for software development for the majority of users.

IDEs consist of a logical 'framework', into which various tools such as editors, compilers and debuggers can fix and then interact with each other. The term IDE could refer to the framework alone or with a combination of several other tools. From now on, we will use the acronym 'IDE' to refer to the combination of the Integrated Development Environment, the debugger, compiler and any other third party plug-ins.

MPLAB-8

Provided for free, the existing MPLAB has been very popular. Although introduced in 1992, and now a very mature product, Microchip are still seeing over 120,000 downloads *per month*, and have sold more than one million development tools over the last year. This is not surprising, as the tools are essential for developing products using Microchip processors, but it does give an indication of the number of customers using these tools. We hobbyist are not in a small community of developers!

New releases of the software have been frequent, as Microchip release new processors and also to provide enhanced development features to help entice customers away from other chip manufacturers.

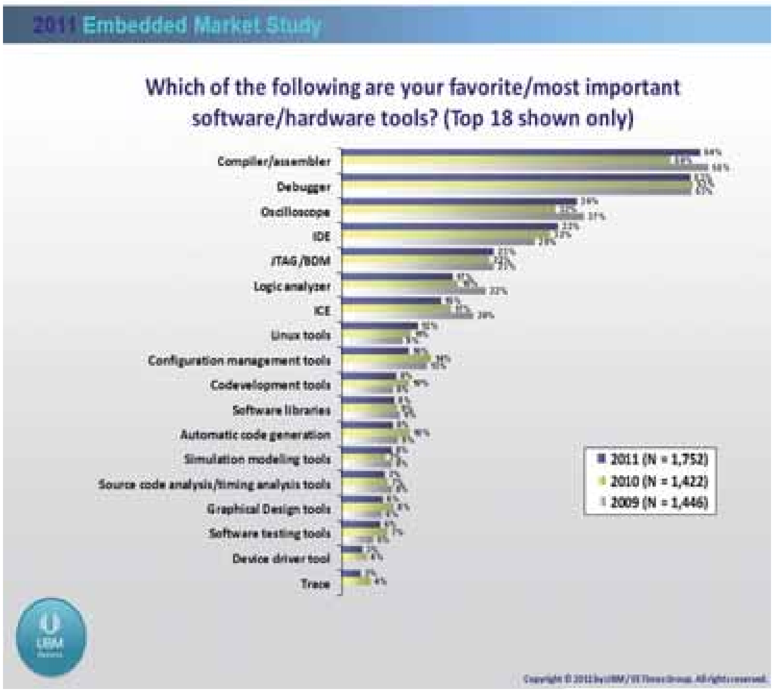

Fig.1. Survey of most important tools

A survey of embedded software engineers taken earlier this year (see Fig.1) shows just how important an IDE is to engineers, as it appears in the top four list of important tools. Although we would have placed coffee in that group too!

MPLAB-X

So what is new about MPLAB-X? What differentiates it from any other upgrade to MPLAB?

Two things: MPLAB-X is a complete rewrite of the IDE, and now provides cross-platform support. That second point is the big one, as MPLAB is now supported on Mac and Linux systems, natively. Not just the editor, but all the tools and hardware drivers.

This cross-platform support has been achieved by porting the compiler, debugger and simulator software to Mac and Linux and by discarding the basic MPLAB-8 framework, replacing it with an existing, Open Source multi-platform IDE called NetBeans.

NetBeans is an Open Source IDE written in Java, tailored to provide an environment for developing mobile, desktop and web software in a range of languages. Why did Microchip choose NetBeans? They evaluated several Open Source and proprietary IDEs, and found NetBeans not only provided the advanced features they wanted, but also that the NetBeans development community was very responsive to the changes and additions that Microchip needed to make.

This is typical of Open Source development; if you are an organisation wanting to participate, it's important to build and be able to build good working relationships with the other developers in the group. Being an Open Source project also means that there are hundreds of developers working on it, providing new features and bug fixes. Your software engineers are often in the minority.

NetBeans is sponsored by Oracle, which, in this case, means Oracle allow some of their engineers to work on NetBeans as part of their main job. This is not unusual, and companies as large as Oracle and even IBM provide significant support to select Open Source projects, which they then use within their organisation (or even sell onto customers). It's a very positive symbiosis, and is a subject worth its own article (or book – there are already several on the subject).

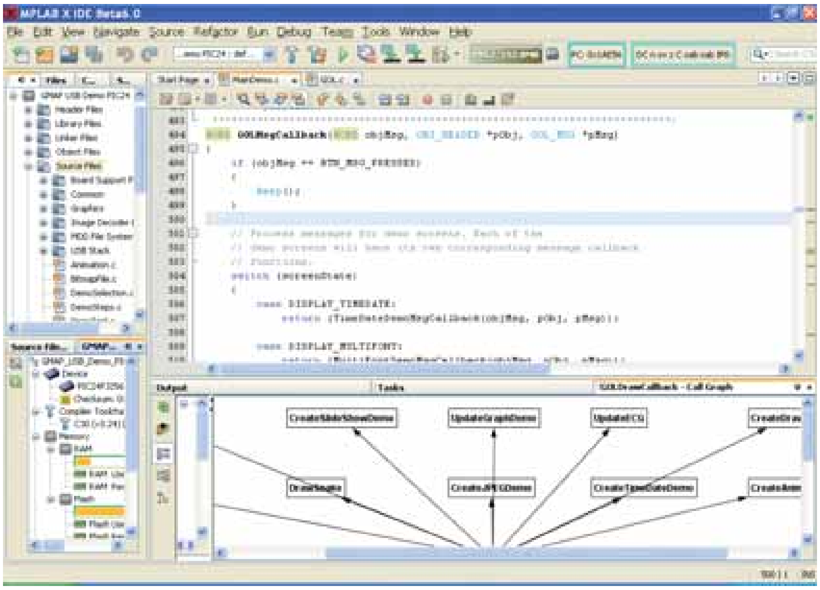

Fig.2. MPLAB-X under Windows XP

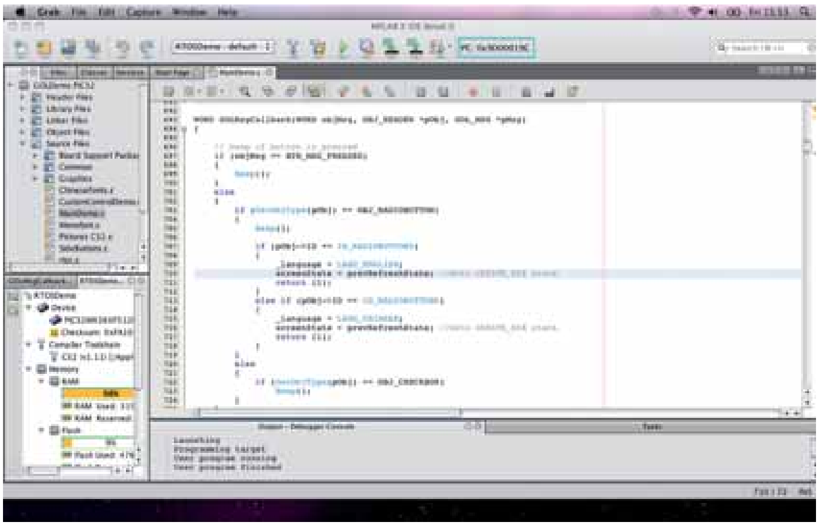

Fig. 3 MPLAB-X under Mac

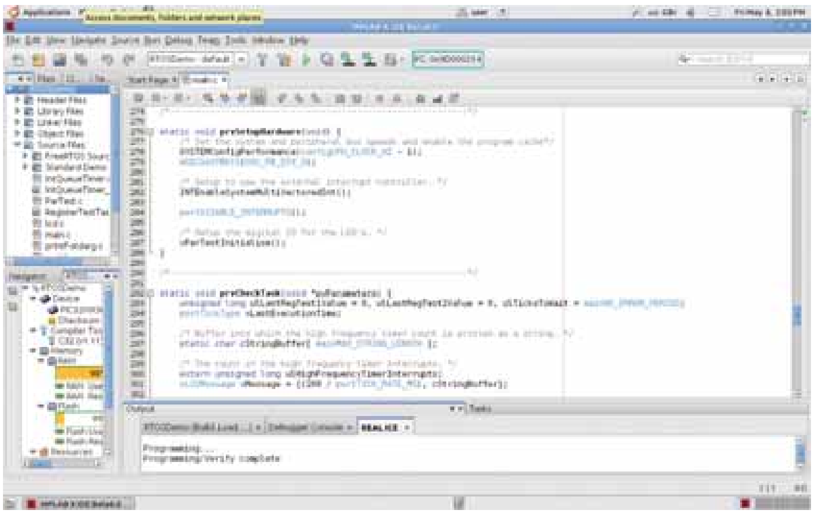

Fig. 4 MPLAB-X under Linux

As the features and supported languages have grown, so has the need for an ever increasingly powerful IDE, providing wider debug tool support and more efficient code editing facilities. The way customers use Microchip products has an effect too as they create increasingly complex products – sometimes with multiple processors requiring simultaneous debugging. The time is right for a major refresh of the supporting software tools, and the IDE in particular.

Look and feel

NetBeans does bring a new look and feel to the user interface, but Microchip have made a considerable effort to make the transition from MPLAB-8 as easy as possible. There is also a very similar look between the three different platforms, as can be seen in Fig.2, Fig.3 and Fig.4.

There will be a transition period for users who are currently committed to MPLAB-8 and do not wish to interrupt their current project's progress. Expect this to last for one to two years, but note that the future is clear, and it's going to be MPLAB-X.

MPLAB-X has been in 'Beta development' for the last 18 months, initially to a number of customers, and then to the community at large. It is currently only available for download on a special forum Microchip have set up for MPLAB-X (emphasising the 'Beta' nature of the release). The link is provided at the end of this article.

Microchip have over 800 microcontroller products available, and MPLAB-X already supports them all. There are a few 'corners' where this isn't quite true yet, such as UART support in the simulator, but Microchip are working hard to supply these. It's a massive task when you think about it, and they are doing well at the moment to improve the support.

New features

There is excellent support for integration with third-party version control software, including the major free products such as Subversion. For those not familiar with version control, this is the way that changes to source code files can be stored in a special database, allowing you to view and compare earlier versions of code, and to add comments to each version to identify the reason for the change. For professional engineers, this is an essential tool, and having it integrated into the IDE is a major bonus.

An unusual addition – one we haven't seen elsewhere – is a built-in version 'history'

feature which acts like a lightweight version control system. By clicking on a 'History' menu button you can see the contents of any file as it has been saved in the past.

A side-by-side viewer allows you to see each change to the file, and provides a simple way to revert sections of code back to an earlier version. This is an excellent feature for hobbyists who have not yet seen the value of a version control system. (Everyone should use a version control system, unless you enjoy pain!)

One of the most interesting new features is the ability to debug multiple processors simultaneously. While not a common setup, having two or more processors on your board can be difficult to debug, if you are tracing one processor while it is talking to another. Now you can debug both within the same IDE, making complex projects easier to work on.

Another good feature is that sections of source code contained within **#ifdef** or **#if** statements will be commented out if they evaluate to false. For the more complex projects (including those using the Microchip Application Library) this will be a major benefit, making it obvious what code will actually be compiled.

Import tool

Moving from MPLAB-8 to MPLAB-X is very simple. MPLAB-X has an import tool, and once a project has been imported MPLAB-X creates a new sub-directory where it holds the new, MPLAB-X specific data. None of your original files are affected, so if you try out MPLAB-X and don't think you are ready for it you can revert back to MPLAB-8 with no extra effort.

Projects created in MPLAB-X cannot be migrated back quite so simply, and, as an aside, it is for that reason that *PIC n' Mix* software projects will continue to be issued under MPLAB-8 (while MPLAB-8 is supported). You are, of course, free to import our project files into MPLAB-X.

Three versions

The IDE is released as three versions – one for the Mac, one for Linux and one for Windows. They all provide identical features. The Windows version runs under XP or later, Mac v10.5 and 10.6. Linux is supported across multiple distributions, with our review conducted on the latest release of Ubuntu.

Why support multiple platforms? Microchip have acknowledged the increasing use of Mac and Desktop Linux (Ubuntu in particular), a strong desire for Open Source tools within academia and the increase in professional acceptance of Open Source development tools generally.

As it is based on NetBeans, the IDE software is released under an Open Source licence – meaning you can get the source code and make your own modifications, at no cost. The Microchip and commercial plug-ins to NetBeans, however, are proprietary and closed, as they have been in the past. Microchip do, however, intend to open up the interface (the Application Programming Interface, or API) to their own tools, which means you will be able to write plug-ins that can talk to, say, the Microchip debugger or compiler and display or utilise that data as you wish. This is a very exciting change, and should result in some very interesting projects to develop new plug-ins.

There are over 670 NetBeans plug-ins already that provide generic IDE-related features (such as spell checkers), and a much smaller set of plug-ins designed to integrate specifically with Microchip features. The area of 'plug-ins' is an uncharted territory. To date, only a few existing ones have been tested with MPLAB-X. For the others, some may be found to be really useful; some may not work 'out of the box', but could be modified to do so. And of course, the opportunity to create new tools previously impossible to make is now available. Interesting times ahead!

Third party plug-ins

We expect there will be an increase in the number and type of third party plug-ins available for MPLAB-X as people find out just how (relatively) easy it is to develop NetBean plug-ins. There is a wealth of examples, experience and support out there on the Internet because the NetBeans IDE is itself so widely used and popular. We look forward to seeing some novel tools in the future. (If anyone is interested, how about a code coverage tool working with the debugger?).

Microchip have set up a dedicated web forum to handle the feedback from users as they ready the IDE for formal release, which must give them quite a headache with all the questions, requests for help and new features coming in. All this across three PC platforms, not just Windows!

As this is a more powerful IDE than MPLAB, one has to ask if those of us with older PCs are going to suffer with slower user interface interaction, or longer build times. The minimum PC specifications are good, at an 800MHz processor and 512MB RAM, and our experience with it was that it is not noticeably slower. Rather surprising given that the IDE is written in Java, but perhaps the developers of NetBeans have given careful thought to the efficiency of their code for us cheapskates.

Comparing the build time of a large project under MPLAB-X on Windows and Linux did show something rather surprising – building under Linux (or Mac, we were told) is *significantly* faster. Even more reason to move away from Windows!

References

MPLAB-X download: **http://devupdates.microchip.com/mplab/**

CIRCUIT SURGERY

REGULAR CLINIC — BY IAN BELL

What's all this noise about?

CHAT ZONE contributor ***alec_t*** posted the following question about simulating noise in LTSpice.

LTSpice provides a noise analysis option, but as far as I can see it does not have a component which can be easily parameterised to simulate a controllable noise source. The only workaround I've managed is to set the Value property of a voltage source equal to 'wavefile=.\mynoisefile.wav', where the wav file is a recording of white noise or similar.

That seems a bit of a kludge. Does anyone know of a simpler method?

A typical random noise signal is shown in Fig.1. Fig.2 shows a sinewave suffering from a significant amount of random noise. These were generated using LTSpice and are what we assume alec_t may be after, although it is not clear exactly what he in wants in terms of the parameterisation and controllability of the noise source. Another possible interpretation of 'controllable noise source' is a signal source which will contribute a specified amount of noise to an LTSpice noise analysis.

Before discussing LTSpice though, we will take a look at some of the basic concepts relating to noise in electronic circuits.

Noise floor

The fact that the components in any electronic circuit or system generate random noise means that there is always a certain level of noise, even with no signal present. The circuit's noise floor relates to noise *within the circuit*, this is different from noise *within the input signal*. If the properties of the required signal are known there are techniques which can extract signals that are smaller than noise present within the signal, for example, due to interference.

There are a variety of types of random noise generated within electronic circuitry, these include: thermal noise, shot noise, flicker noise, and avalanche noise. This noise generated is fundamentally due to the discrete nature of electricity at the atomic level – electric charge in circuits is carried in packets of fixed size on electrons.

Random noise may be classed according to the frequency, or range of frequencies, present. White noise has the same power throughout the frequency (*f*) spectrum, whereas $1/f$ noise (or pink noise) decreases in proportion to frequency. For $1/f$ noise, there is the same amount noise power in the bandwidth of say 100Hz to 1kHz as there is in 1kHz to 10kHz, whereas for white noise there would be 10 times as much power in the bandwidth 1kHz to 10kHz as 100 to 1kHz, because it is 10 times larger.

The difference between the signal and the noise is often of great importance. It is expressed as the signal-to-noise ratio (SNR), usually in decibels (dB) and based on the ratio of noise *power* (hence the v^2 terms in the equation):

$$SNR = 10\log_{10}\left(\frac{v_s^2}{v_n^2}\right)$$

Where v_S is the rms signal voltage and v_n is the rms noise voltage. When using or quoting SNR values, the bandwidth (range of signal and noise frequencies considered) should be quoted because noise power is frequency dependent and noise may be present well outside the range of signal frequencies of interest.

Thermal noise

Thermal noise (also known as Johnson noise) is a fundamental property of resistors (including the internal resistances of sensors and semiconductor devices), which results in a white-noise voltage across the terminals of any resistor, even when it is not connected in a circuit. This is a fundamental property of any resistor, so whatever we do we cannot get lower noise than the thermal noise. Thermal noise cannot be reduced by improved component manufacture, however, as it is temperature-dependent, reducing the temperature will reduce the noise.

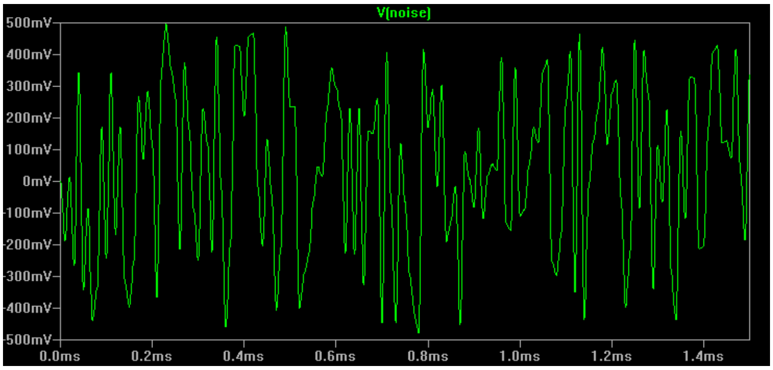

Fig.1. Random signal generated using LTSpice

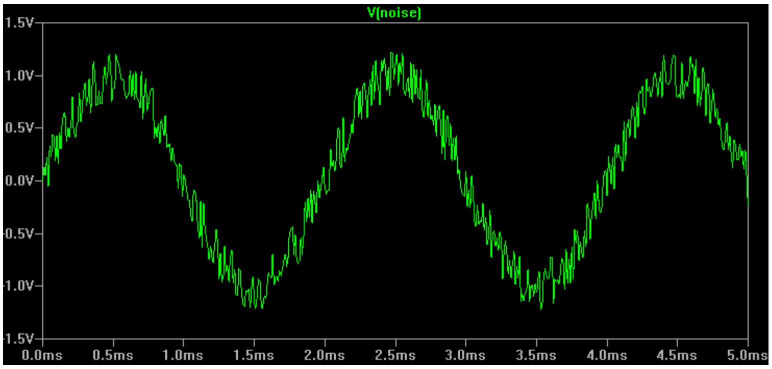

Fig.2. A noisy sinewave generated using LTSpice

The thermal noise rms voltage across a resistor is given by:

$$v_{N,rms} = \sqrt{4kTR\Delta f}$$

Where k is a physical constant known as Boltzmann's constant ($1.38\times10^{-23}JK^{-1}$ (joules per kelvin)), T is the temperature in kelvin (K), R is the resistance in ohms (Ω), and Δf is the bandwidth of interest in hertz (Hz) (ie, the range of frequencies over which you are measuring the noise). Δf is pronounced 'delta f', the delta symbol means 'change in' and so Δf represents a range of frequencies.

The fact that a bandwidth has to be specified in order to get a noise voltage means that noise figures are often expressed in 'volts per bandwidth unit' form rather than simply as voltages (have a look on datasheets for ICs such as op amps and you will see noise figures expressed this way). This value is known as noise density. If we divide both sides of the above equation by the square root of the bandwidth ($\sqrt{\Delta f}$) we get:

$$\frac{v_{N,rms}}{\sqrt{\Delta f}} = \sqrt{4kTR}$$

The value $\sqrt{4kTR}$ has units 'volts per root hertz' often written as $V/Hz^{1/2}$ or $V/\sqrt{Hz}$. So, for example, the noise from a 1kΩ resistor at 27°C (300K) is:

$$\sqrt{4\times1.38\times10^{-23}\times300\times1\times10^{3}}$$
$$= 4.07nV/Hz^{1/2}$$

If we were interested in a bandwidth of say 20kHz, the thermal noise voltage from this resistor would be:

$$4.07nV\times\sqrt{20\times10^{3}} = 576nV$$

Statistical analysis of the properties of thermal noise shows that the instantaneous peak noise voltage will be less than five times the rms (average) value for 99% of the time.

Shot noise

When current flows through a resistance (in a resistor or active device) it will generate additional white noise above the thermal noise due to the quantum nature of electric current at the atomic level (electric current is the flow of discrete charge carries – eg, electrons), rather than a 'continuous' flow. This noise is known as 'shot noise' and, like thermal noise, is due to fundamental physics and cannot be reduced. For an applied current of I in amps (A) the shot noise is given by:

$$I_{N,rms} = \sqrt{2eI\Delta f}$$

where e is the electronic charge (charge on one electron = $1.6\times10^{-19}C$ (coulombs)) and Δf is the bandwidth as before. For a current of 1μA, this is $0.57pA/Hz^{1/2}$, which is about 80pA over a 20kHz bandwidth. Shot noise is an important source of noise in semiconductor devices such as diodes and transistors.

Flicker noise

In addition to thermal noise and shot noise, resistors and active devices produce yet more noise for various and often complex reasons. This noise is called 'flicker noise' and takes the form of $1/f$ noise, typically having a $1/f$, or similar, relationship with frequency.

Unlike thermal and shot noise, the flicker noise in resistors (and other devices) depends on the component type and manufacture, and can even vary quite widely for components of the same type. For a decade bandwidth (frequency range of 1 to 10 times), the flicker noise for typical resistors varies from tens of nanovolts to a few microvolts, depending on type and quality. Carbon composition resistors produce the highest flicker noise and wirewound resistors the lowest.

Avalanche noise

Avalanche noise is produced by Zener diodes (or other diode junctions undergoing Zener or avalanche reverse breakdown). Avalanche noise is much larger than shot noise and so Zener diodes can introduce a lot of noise into a circuit. For this reason, they should be avoided in low noise circuits, even though they are a temptingly easy way to produce a stable voltage reference. On the other hand, this may be useful if what you need is a source of noise.

Noise is not necessarily modelled in a very detailed way in Spice simulators, for example resistor noise models may only include thermal noise.

Input or output reformed

The noise (density) produced by a circuit can be input referred, or output referred. This is illustrated in Fig.3. The total noise produced by a circuit (Fig.3a) can be seen as equivalent to replacing the circuit with a noise-free version and accounting for the noise by adding a noise voltage source to the input or output to represent all the noise the circuit (Fig.3b and Fig.c).

The value of the input and output noise are related by the circuit's gain with respect to the input noise source. In a similar way, the contribution of any individual component in the circuit can also be represented by an input-referred or output referred value.

The LTspice analogue simulator to which alec_t refers can be downloaded free in its full form from the Linear Technology website, **www.linear.com/designtools/software/**. The 'Spice' part of the name refers to the acronym of 'Simulation Program with Integrated Circuit Emphasis' – a *de facto* industrial standard for computer-aided electronic circuit analysis with many commercial versions. It was originally developed in the early 1970s at the University of California, Berkeley.

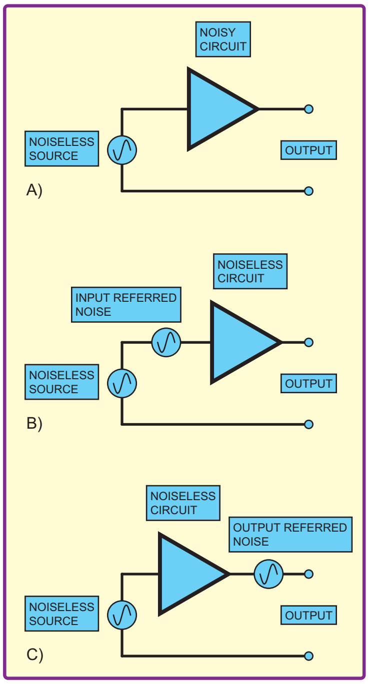

Fig.3. Representing noise. (a) A noisy circuit is driven by a noiseless signal source. (b) The circuit noise represented by an input referred noise source driving a noiseless version of the circuit (c) similarly, output referred noise

As alec_t indicates, LTSpice, in common with most other SPICE simulators, has a noise analysis capability. Spice noise analysis works out the noise produced by each component using formulae such as that for the resistor discussed earlier. We will start by looking at this, before showing how we can generate a random signal like that in Fig.1, and discuss how this differs from noise analysis.

The circuit in Fig.4 can be used to demonstrate noise analysis. The voltage source is noise free (it is an ideal voltage source as far as the noise analysis is concerned), so the noise contributions to the output (at node *pd*) will be due to the two resistors. Using the value from the calculation we did earlier, each resistor will

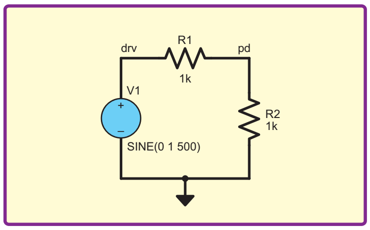

Fig.4. A simple circuit to illustrate noise analysis in LTSpice

produce a noise density of 4.07nV/Hz½ at a temperature of 27°C, which is the default simulation temperature for LTSpice.

Circuit gain

Noise calculations have to take account of the effective circuit gain from each component to the output. For the circuit in Fig.4, the gain with respect to the noise from each resistor is 0.5, due to the potential divider effect of the two equal resistors. Thus, each resistor contributes 0.5×4.07 nV/Hz½ = 2.035nV/Hz½ of noise to the output signal at node *pd*.

LTSpice calculates the individual noise contribution of each component and is able to plot these against frequency. These are output-referred values, but they can be divided by the input-to-output gain of the circuit to find the input-referred noise contribution.

LTSpice will calculate the total noise density due to all components in the circuit. To do this, the square of the noise density is multiplied by the square of the gain relevant to each component, and these values are totalled (squares because this is a power-based calculation). This gives the square of the output-referred total noise density – taking the square root gives the noise density. As with individual components, dividing the output referred noise density by the input-to-output gain of the circuit gives the input-referred value.

As resistor noise is equal at all frequencies, and the gain from both R1 and R2 to the output is 0.5, the total output noise density for the circuit in Fig.4 due to the two resistors contributions of 4.07nV/Hz½ will be:

$$\sqrt{(0.5)^2\left(4.07\times10^{9}\right)^2+(0.5)^2\left(4.07\times10^{9}\right)^2}$$

which is 2.88nV/Hz½ at all frequencies (output referred). The input to output gain (from node *drv* to node *pd* in Fig.4) is 0.5, so the input referred noise is 2.88/0.5 = 5.76nV/Hz½ at all frequencies. In more complex circuits we would have to take account of the frequency dependence of noise from active devices, and the gain calculations would be more difficult and frequency dependent, but LTSpice will do that work for you.

Noise analysis

To run a noise analysis, select Edit Simulation Command from the Simulation menu while in the schematic editor. In the Edit Simulation Command window, select the Noise tab and fill in the parameters as required (see Fig.5).

The Output parameter is written as V(*x*) where *x* is the node in the circuit which will be regarded as the output for noise analysis (*pd* in this example). The Input parameter identifies a voltage or current source, which is the input to the circuit, and to which input referred noise will relate.

The remaining parameters determine the range of frequencies over which the noise analysis will take place, and the frequency points at which LTSpice will make noise analysis calculations. Click OK, and then on the schematic, to complete setting up the command.

Running the noise analysis will cause a blank waveform window to open. Right click this and select Add Traces. For the example circuit in Fig.4 you will be able select the following noise values to display:

V(inoise)	Input referred total noise
V(onoise)	Output referred total noise
V(r1)	Output referred noise contribution from R1
V(r2)	Output referred noise contribution from R2
gain	Gain of the circuit from input to output

The 'input' and 'output' are as specified in the noise analysis command set up in the window shown in Fig.5. Results from the analysis of the circuit in Fig.4 are shown in Fig.6. The values agree with our calculations above. Note that the noise density scale is on the left and the gain scale is on the right.

AC analysis

The noise analysis we have been discussing does not involve waveforms which we can 'see', as we would when looking at a noisy signal on an oscilloscope (like Fig.1 and Fig.2). The noise analysis performed by Spice is related to AC Analysis, which is typically used to plot circuit gain and phase shift against frequency. To perform a time-based simulation of a noise signal we have to address a couple of potential problems, first that noise has infinite bandwidth and second that it is random.

The problem with the large bandwidth of noise is that the noise voltage changes will occur much more rapidly than in the signal of interest. This is clear in Fig.2 – the noise has a much higher apparent frequency than the sinewave. From a simulation point of view, this implies we need much longer run times for (say) a sinewave plus noise, than for just the sinewave. We have to make sure the simulator uses a sufficiently small time step in its calculations; otherwise it will miss the detail in the noise. If you want to simulate noisy signals in the time domain you need to take account of this.

Random numbers

The second issue is that noise is random, so to simulate a noisy signal we have to generate random numbers. There are a number of computer algorithms which will do this; actually they produce pseudorandom numbers – sequences of values which have statistical properties close to true random values, but which are

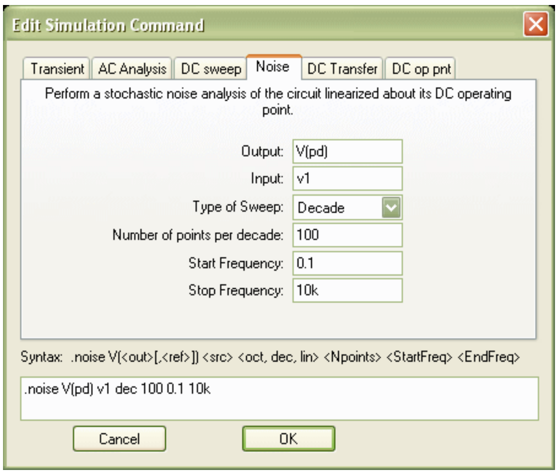

Fig.5. Setting up a noise analysis in LTSpice (for the circuit in Fig.4)

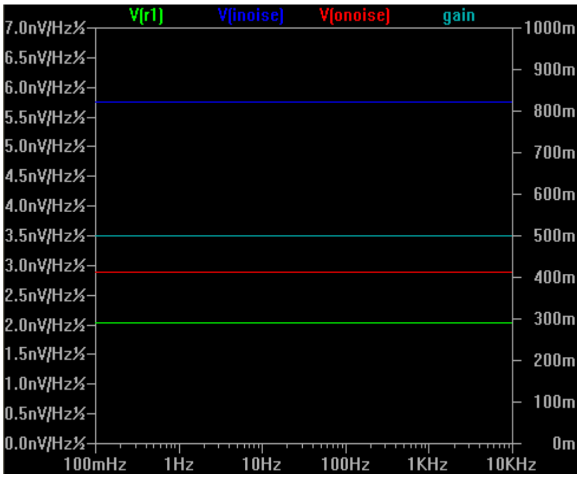

Fig.6. LTSpice noise analysis results for the circuit in Fig.4

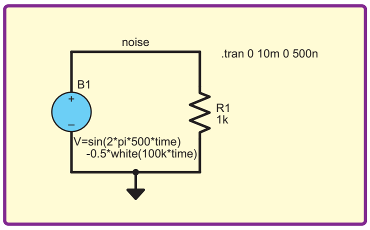

Fig.7. LTSpice schematic for generating a sine-plus-random waveform. The source will not contribute to a Spice noise analysis

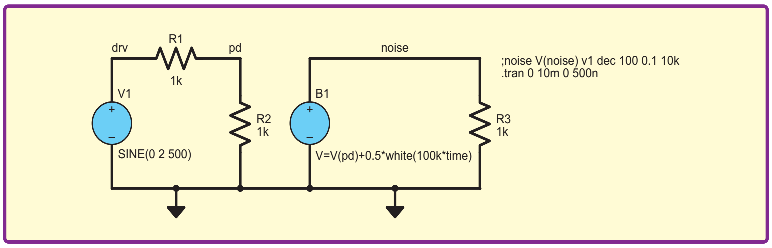

Fig.8. LTSpice schematic for adding a random waveform to a copy of an existing signal. This signal will also inherit noise analysis contributions from the original

in fact fully predictable. Fortunately, we do not have to work this out from scratch to simulate noise because LTSpice provides random number generation for us.

The usual voltage and current sources (*V* and *I* components) which we use for power supplies and signal sources in our simulation can provide DC, sinewaves, pulse trains, exponentials, decaying sinewaves, frequency-modulated sinewaves and arbitrary waveforms using piecewise linear (PWL) or .wav file based definitions. The latter, as alec_t points out, can be used for a random signal, but is inconvenient if you do not have a suitable file available.

The *V* and *I* components do not have a built-in random signal capability, however, they are not the only signal sources provided by LTSpice. On the basic component list you will also find BV and BI. These are arbitrary behavioural voltage or current sources.

The term behavioural refers to the approach to modelling circuits in terms of their behaviour rather than by drawing a schematic of their actual physical implementation. This approach is useful for modelling electronic systems before a fully detailed design is performed, to check that the concept of the design is valid. Such models are also useful for manufactures of ICs, such as op amps.

Mathematical expressions

The arbitrary behavioural voltage or current sources in LTSpice allow the voltage to be set using a mathematical expression. These expressions can use node voltages, node voltage differences, circuit element currents, *time* (the current time in the simulation) and the constant *pi*. The expressions can be built using a set of mathematical functions such as +, –, sin(*x*), max(*x*,*y*), sqrt(*x*) and log(*x*) – like those you would expect to find on a scientific calculator. For the full list consult the LTSpice help on BV and BI.

The available mathematical expressions include random number gen-erators rand(*x*), random(*x*) and white(*x*). These all produce a random number depending on the integer value of *x* (imagine a look-up table of random values, indexed by *x*). rand(*x*) and random(*x*) produce numbers in the range 0 to 1, whereas for white(*x*) the range is –0.5 to 0.5. The functions also vary in terms of the smoothness of transition of one value to the next, with white(*x*) being the smoothest.

If we make *x* equal to *time,* these functions will produce a random value which varies with simulation time – in other words, a 'noise' waveform. However, because the numbers are pseudorandom, the same random waveform will be produced each time a simulation is rerun.

Random valves

To set up a random voltage source add a BV element to your schematic and edit the value attribute, which defaults to *V=F(...)*, to something like *V=rand(time)*. This will give you a random waveform varying between 0 and 1V. Modify the expression to create the voltage levels required. For example *V=1+2*rand(time)* will give you a 2V peak-to-peak random signal on top of 1V DC.

The function rand(*x*) produces a different random value for each integer *x*, so *V=rand(time)* will cause the voltage to change every second. We will probably need it to change faster than this, which is easily achieved by multiplying time by an appropriate value. For example, to get a new voltage every 10μs, multiply time by 100,000 (1 divided by the required update interval), writing the value attribute as *V=rand(100k*time)*.

To create a signal with randomness added to it we can use the other mathematical functions available with the BV source to define the signal, for example, for a 1V, 500Hz sinewave, with 0.5 peak-to-peak random signal superimposed use:

V=sin(2*pi*500*time)+0.5white (100k*time)

This is the signal shown in Fig.2. The LTSpice schematic is shown in Fig.7. The signal produced by B1 will not contribute to a noise analysis, we will return to this fact shortly.

The mathematical expression for the BV source can also refer to other node voltages, so we can take an existing signal and add the random waveform to a copy of it. For example, Fig.8 shows the circuit we used earlier with a 0.5V peak-to-peak random signal added:

V=V(pd)+0.5*rand(100k*time)

This will also produce a 1V sinewave the random signal added, as in Fig.2.

If you run a noise analysis of the circuit in Fig.8, with V1 as the input and *v(noise)* as the output, the figures will be the same as those for Fig.5. The random signal will not contribute to the noise analysis because all voltage sources are noise-free as far as the LTSpice noise analysis is concerned, whatever signal they are producing. This also applies to Fig.7, as we noted earlier. Resistor R3 does not contribute noise in this case because the noise node is driven directly by the ideal voltage source B1.

If you would like the noise analysis to be at least approximately compatible with your random signal, then the circuit in Fig.8 may be useful. By contriving suitable resistor values, and/or multiplying the signal at the node *pd* by a suitable factor in the expression for the BV source, the noise node can have any noise contribution you like. We can make the original sinewave very small (eg, microvolts) so that it gets scaled up to the right level by the same factor which is boosting the noise contribution. For example, by setting:

V1 to V=SINE(0 2u 500)

B1 to V=1e6*V(pd)+0.5*white (100k*time)

we get the same sine-plus-random waveform as before and 2.88mV/Hz^{½} of noise analysis contribution from B1 (rather than the nanovolt levels at node *pd*). This value is not meant to be equal to that of the random signal; this just illustrates the possibility of controlling the noise analysis contribution.

Alec_t asked for a parameterised and controllable noise source in LTSpice, but we are uncertain about exactly what his requirements are. Hopefully, the discussion here will have provided some inspiration for achieving what he wants.

By Robert Penfold

INTERFACE

Long-lived converters

IN THE world of computing and electronics, it tends to be taken for granted that things will be forever changing, and that the latest gizmos of today will be obsolete by tomorrow. However, there are some electronic gadgets, components, or whatever, that do 'buck the trend' and remain available and in use for many years.

When it comes to electronic components, I suppose that there are few examples of semiconductors that have managed to stay in production from one decade to the next. Most of those that have managed this feat are simple devices such as transistors and diodes. Some of these must be approaching their golden jubilees!

There are very few integrated circuits that manage to remain current for many years, but there are some. These are mostly the devices that became the 'industry standards' of their day, and for many applications have not been replaced by anything better.

Standard A/D

Many of the analogue-to-digital (A/D) and digital-to-analogue (D/A) converters featured in *Interface* articles over the years have disappeared from the marketplace. By contrast, the National Semiconductors ADC0800 and DAC0800 series of chips (Fig.1) are early devices, but have remained in production while many of their competitors have become obsolete. They still represent an attractive option for many applications, as they offer excellent performance but are now relatively cheap. Another advantage is that they can still be obtained in easy-to-use DIL packages, although surface-mount types are also available if you should need them.

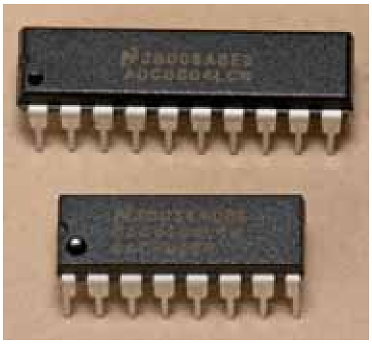

Fig.1. Unlike many computer related chips these days, the DAC0800 and ADC0804 are available in standard DIL plastic packages. They are also available in other forms, it is devices with an 'LCN' suffix that have a DIL package

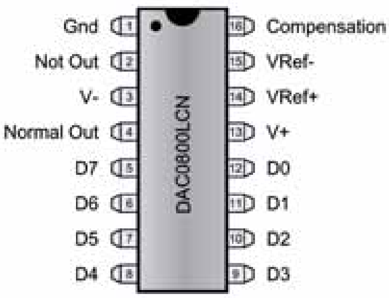

Fig.2. The pinout diagram for the DAC0800LCN. Unusually for a computer interface chip, it operates from dual balanced supplies, but the digital inputs still operate at standard 5V logic levels

The DAC0800 is the digital-to-analogue converter, and it is an 8-bit type that has parallel inputs that operate at standard CMOS or TTL logic levels. The pinout diagram for the DAC0800LCN, which is the standard 16-pin DIL version, is shown in Fig.2.

Many D/A converters operate from a single +5V supply and provide an output voltage range that is typically from 0 to 2.5V. Signal processing is then used to provide the required output voltage range.

The approach taken with the DAC0800LCN is different, and it operates from dual balanced supplies, rather like an operational amplifier (op amp). No +5V supply is required. It can provide a large output voltage range without the need for any amplification, although in most applications it is necessary to at least use some buffering at the output.

There are actually two outputs terminals, which are the Normal and Not types. The Not output is at zero volts with an input value of 128, with higher values raising the output voltage in the positive direction. Lower values send the output negative.

An opposite action is obtained at the Normal output, with high input values producing negative output potentials, and lower values giving positive output voltages. An output voltage range of something like –12V to +12V is easily achieved without using any external amplification.

Current sinks

The voltage changes at the two outputs might seem slightly illogical, with the two outputs operating with the opposite sense to what one might

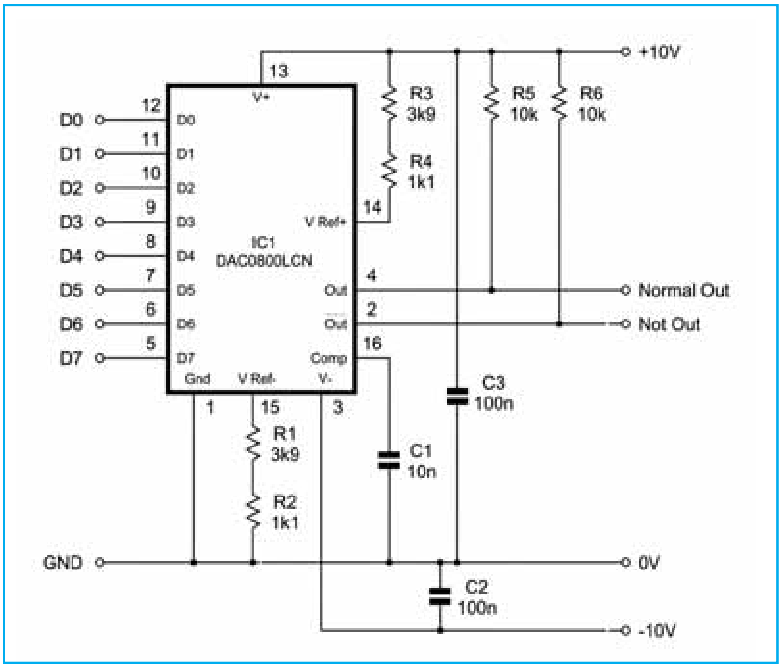

Fig.3. The basic DAC0800LCN digital-to-analogue converter circuit. The +10V supply also acts as a reference voltage

reasonably expect. The reason for this is that the outputs are actually current sinks, and the input values are converted to corresponding output currents.
Using load resistors at the output produces a simple voltage to current conversion, but the higher the output current, the greater the voltage developed across the load resistors, and the lower the output voltage. Hence higher values result in the voltage at the Normal output heading in a negative direction.

This ability to produce positive and negative output voltages, together with the anti-phase outputs, is clearly a bit 'over the top' for many applications. However, in the right applications it can greatly simplify matters. For example, with a computer controlled power supply that must provide dual balanced outputs there is no need for any circuits to generate an accurately balanced negative voltage from the positive output signal from the converter. The DAC0800LCN can provide suitable negative and positive output potentials.

The resolution is only seven bits for each polarity, but this gives 127 different output levels for each one, which is perfectly adequate for many purposes. Actually, the output is slightly lopsided in that there are 128 positive output voltages from the Normal output, but only 127 negative ones. The missing negative output voltage is sacrificed to provide the central 0V output level. There are other operating modes available, including unipolar types, but there are probably better alternatives available unless bipolar operation is needed.

Basic DAC0800LCN circuit

The basic converter circuit for a DAC0800LCN is shown in Fig.3. This chip does not have built-in data latches, and the 8-bit input bus (D0 to D7) must therefore be fed from a latching output port. C1 is a compensation capacitor that is needed to prevent instability, as are supply decoupling capacitors C2 and C3. R5 and R6 are the load resistors at the Normal and Not outputs respectively. These must be high quality components, having low tolerance figures and good thermal performance, since errors in their accuracy will cause corresponding errors in the output voltages.

In this circuit, they are fed from the main +10V supply rail, which must be highly accurate and stable as it is also acting as a reference level. It is not essential to use the positive supply rail as the reference voltage, and it is perfectly acceptable to power the circuit from something like dual 12V supplies while using a separate reference source for R5 and R6.

Resistors R1 and R2 provide reference currents to the V Ref- input, and the equivalent function is provided by R3 and R4 at the V Ref+. If a separate positive reference level is used,

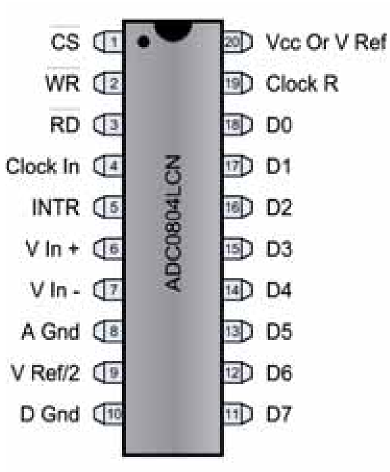

Fig.4. Pinout details for the ADC0804LCN. It is designed to interface to the buses of an 8080 microprocessor, but it can also be used in stand-alone applications with the aid of some control logic

R3 and R4 should be fed from this instead of the positive supply rail. For optimum accuracy, R2 and R4 can be replaced by high quality 2.2kΩ preset resistors (potentiometers). These are then adjusted for 0V at their respective outputs with an input value of 128.

ADC0804LCN

The fact that the ADC808x range of analogue-to-digital converters were designed to interface easily to the buses of an 8080 microprocessor indicates that it is not exactly a new series of devices. Although designed for easy use with an 8080, these chips will operate just as well in the role of conventional analogue-to-digital converters when combined with some simple control logic and an 8-bit input port. The the chips in the ADC080X series are essentially the same, and they differ only in their operating temperature ranges, packages, and degree of accuracy.

The ADC0804LCN featured here has a standard 16-pin DIL plastic package, operates over a temperature range of 0°C to 70°C, and has an accuracy of +1 LSB. Its pinout diagram is shown in Fig.4, and the basic circuit for an analogue-to-digital converter using this device is shown in Fig.5.

The circuit is powered from a +5V supply, which must be highly stable as it also acts as the reference voltage when using the basic configuration of Fig.5. The supply current is no more than 2.5mA. D0 to D7 are the eight digital outputs, which are tristate types. When not used with the data bus of a microprocessor, they can be used with any input port that operates at normal 5V CMOS or TTL logic levels.

There are separate digital and analogue ground terminals, which can help to avoid problems with digital noise being coupled into the analogue circuits. However, in most cases they are simply wired to the 0V supply rail using the shortest possible connections.

The circuit responds to the voltage difference between the two analogue inputs, but differential operation is not needed in most applications. The V In– input is then connected to the 0V supply rail, and the input voltage is applied to the V In+ input.

The reference voltage is normally the 5V supply rail, but the range covered by the converter can be altered by altering the voltage at pin 9, which is normally at half the reference potential. By using this feature and the differential inputs it is possible to

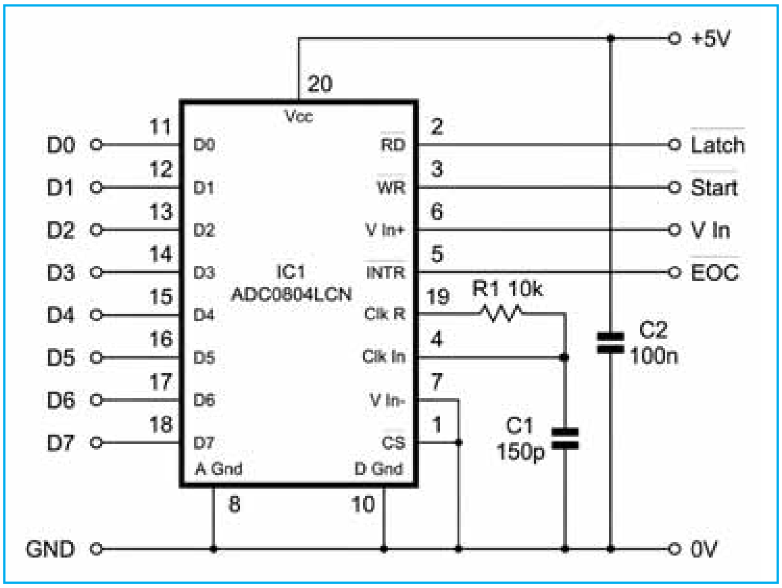

Fig.5. A simple digital-to-analogue converter based on an ADC0804LCN. The +5V supply rail also acts as the voltage reference source

obtain virtually any desired input voltage range, but this is not a topic that will be pursued further here.

Speed

The ADC0804LCN is a successive approximation converter, and as such it is not particularly fast. An external clock signal can be applied to pin 4, or the simple *C-R* clock circuit built into the chip can be used. The built-in clock oscillator will usually suffice, and this is a simple relaxation type.

In Fig.5 the timing components are C1 and R1. The output frequency in hertz is approximately equal to 1/1.1CR, which is something over 700kHz using the specified values, although it is likely to be a little lower in practice due to the internal capacitance of the chip. Optimum accuracy is achieved at around 640kHz, so the specified values should give good results.

The absolute maximum conversion rate for the ADC0804LCN is just under 10000 conversions per second, and in practice it is likely to be significantly less than this. While a rate of a few thousand conversions per second is clearly inadequate for some applications, it is more than adequate for most. Anyway, when using a virtual serial port to interface the circuit to a PC, it could well be the port, rather than the converter, that is the limiting factor.

In control

When using a digital-to-analogue converter, it is not normally necessary to have any form of handshaking with the computer, or to have any control logic. It is simply a matter of outputting values to the converter, which almost immediately produces a change in the output voltage.

Matters are not as simple as that with an analogue-to-digital converter. Either the computer must monitor and control the converter circuit via some input and output lines, or some control logic must ensure that everything happens in the right order. The second method is preferable, since it avoids the need for extra input and output lines. An 8-bit input port is all that is needed.

A conversion is initiated by having the $\overline{\text{CS}}$ (chip select) and $\overline{\text{WR}}$ (write) inputs at logic 0. When not interfacing the chip direct to a microprocessors bus, it is possible to simplify matters by tying the CS input low and applying the start conversion pulse to the $\overline{\text{WR}}$ input.

The $\overline{\text{INTR}}$ (interrupt) output goes low when the conversion has been completed, but in the present context this is used to indicate to the control logic that fresh data is available. A low pulse on the $\overline{\text{RD}}$ (read) input latches the data onto the data outputs and also resets the $\overline{\text{INTR}}$ output.

At this point, a signal must be supplied to the virtual serial port interface so that it transmits the new byte of data. The computer's hardware and software will then detect and read the new data, thus avoiding the need for monitoring of, or handshaking with, the converter circuit via additional input and output lines.

These two chips will feature in future *Interface* articles, but in the meantime it is a good idea for anyone interested in using them to obtain the relevant data sheets. These are readily available as free downloads on the Internet, and any good search engine should locate a number of sources.

Max's Cool Beans

By Max The Magnificent

Interesting times

Have you heard the saying 'May you live in interesting times'? I was always under the impression that this was a translation of a Chinese curse (or proverb, depending on your point of view). According to Wikipedia, however, the Chinese language origin of the phrase, if it exists, has not been found. I love Wikipedia; there's always so much to learn. For example, I was interested to discover that the 'interesting times' phrase is actually supposed to be one of three curses of varying severity, the others being 'May you come to the attention of those in authority' and 'May you find what you are looking for.'

Well, earlier this year, I found myself living through some interesting times of my own. As you may or may not recall, I am based in Huntsville, Alabama, USA. I moved here from England twenty-one years ago for the nightlife (that's a little Alabama joke right there [grin]). On Wednesday, 27 April, in addition to torrential rain and raging winds, more than 300 tornadoes ravaged Alabama and nearby states – I've been told that this is the most tornadoes in one day in living memory. Well, a number of these tornadoes ripped through Huntsville and surrounding areas.

It's amazing what one takes for granted in this high-tech world of ours… until things stop working. In addition to numerous power lines coming down, one tornado took out the main towers and power feeds coming out of the local Browns Ferry Nuclear Power Plant. We also lost a lot of wireless towers around the same time. I heard that 600,000+ people ended up without power in north Alabama. No power; no Internet; and virtually no cellphone access – the result was a strange new world.

Tornado warning

I was in my office at work when the first wave of storms hit, mind-locked with my computer and totally unaware of what was going on around me. So it came as something of a surprise when the guy in the office next to mine stuck his head through my door and said: 'There's a tornado headed this way, we're all moving to the safe room downstairs.'

'Oh dear,' I thought (or words to that effect). So I ambled downstairs and was milling around with the other guys when my wife, Gina, called to say that a storm cell had passed right over our house and the power was out and she was not happy. So as soon as we had the all-clear at the office, I leapt into my car and made a break for home. A few miles from my house the gauge on my car started flashing to tell me I was almost out of gas (petrol). 'No worries,' I thought, 'I'll fill her up tomorrow.' Of course, I didn't realise that we were destined to be without power for almost a week and – without power – the gas stations can't pump gas.

Gina and I and our son Joseph and our two stupid cats and our two even more stupid dogs spent the evening camping out on the floor of our laundry room listening to the radio by candlelight. We could hear the storm raging overhead and feel the house shaking, but we didn't realise just how bad things were out there.

The next morning we discovered that many nearby areas had been totally devastated; for example, if you use Google to look up 'Tornado Anderson Hills Huntsville Alabama' – a subdivision that is located just a few miles from our house – you will be amazed to see just how powerful these storms can be. Our own neighborhood took quite a beating, with lots of trees down and houses missing siding and shingles and suchlike. Much to our amazement, however, our house came through totally unscathed. We were also fortunate in the fact that the main water supply kept working, otherwise we really would have been in dire straits.

We ended up being without power for six long days. Fortunately our families and friends came through this alive, and if this experience has tought me one thing – I will never take the so called small luxuries, hot water, electric lights, TV etc., for granted again!!

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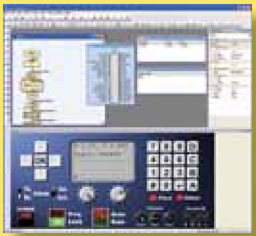

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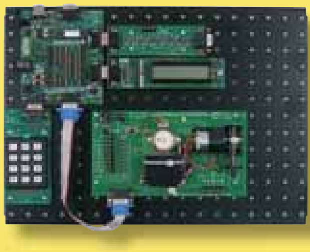

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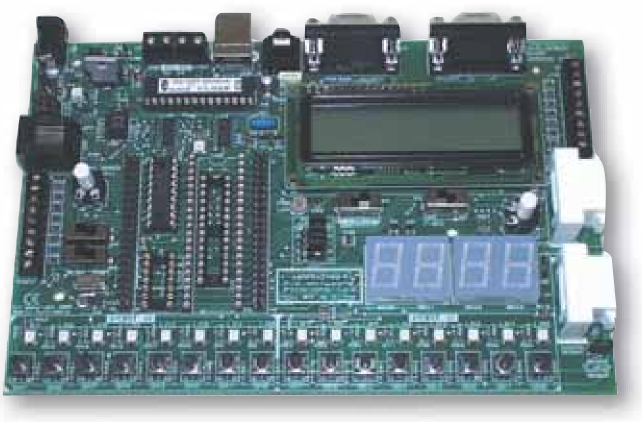

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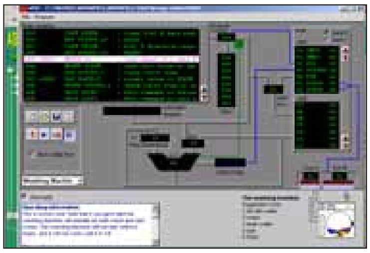

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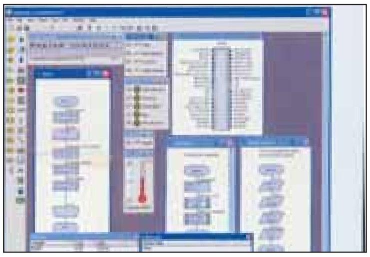

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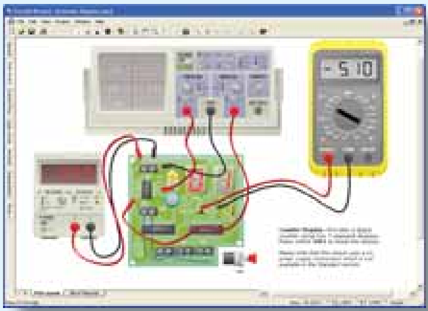

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READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly

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☆ LETTER OF THE MONTH ☆

Lightning speed is not what you want!

Dear Editor
I've been running Ethernet cable around the house to couple three computers and a media player, a laptop is also connected via WiFi. Fortunately, I hadn't finished and only one computer was connected because there was a particularly violent thunderstorm during the early hours of one morning. When I switched on the computer I was greeted with a black screen and error messages about a non-standard PCI bus.

I couldn't get past the errors, nor could I access the BIOS. Some time later, I had the computer up and running, however, the on-board Ethernet controller was fried, likewise the modem and the WiFi router. Everything had switched off at the mains, the only connection was via a phone line and Ethernet cable between the computer, modem and router.

It seems likely that a lightening strike, either on or near the overhead phone line caused a surge, which passed through my equipment, destroying everything in its path. I'm connected via WiFi at the moment, I don't get a very good signal, the walls of my house are stone and up to two-feet thick in places, the signal also is much lower when it's raining – I suspect humidity must be having some effect here – but I think I'll stick to WiFi for the time being.

I also had an external USB hard drive connected to the media player so that I could watch video files, but the Viewsonic media player has just croaked on me. It is under guarantee and it failed some weeks after the lightening strike, so I don't think the two are connected.

One final, but unrelated point – in *Net Work*, Alan Winstanley states that all devices have to share the same phase, the attached pdf [supplied to AW] shows that signals can be copied across phases. Not sure if I'd want to be faffing about with three phase, but at least it's possible, in theory.

Alan Jones, by email

Alan Winstanley replies:

Very interesting comments, thank you. I do sympathise and, although yours is quite an extreme example, I can believe how a lightning-induced surge could be transmitted over the phone lines and through a router, taking out any network equipment connected at the same time.

With Internet-connected large-screen TVs and media network players finding their way onto home networks, I think the risk of key equipment suffering substantial lightning damage is becoming a real one. As a habit, I try to disconnect everything from my phone lines whenever a major thunderstorm is passing close by.

My desktop PCs have uninterruptible power supplies and sensitive mains equipment is connected through surge-suppressed mains adaptors to offer a modicum of protection. Some suppressed powerstrips have AV or phone line protection too, along with insurance policies to cover the cost of any damage caused to connected equipment. Short of unplugging everything and crossing your fingers, there isn't a lot more that you can do to guard against lightning damage.

You could consider wireless repeater units (aka range extenders) to extend your WiFi coverage through the building. Amazon lists quite a few. TP Link models have been recommended to me.

I had excellent service from Viewsonic when my monitor failed, they have been very good and replaced it without question. I've had two or three Viewsonics and I can generally recommend them.

Thanks for your interest, regards

Alan Winstanley

Cool Beans and Spirules

Dear Editor
A big 'thank you' to Max for pointing out the full potential of Dropbox. It is a utility I've been using for some time, but had singularly failed to spot its potential to create copies and file share across multiple desktops and even my Xperia X10 mobile.

May I also thank you for the current *Teach-In 2011* series, which has provided a useful re-introduction to the world of discrete electronics. I speak as a control engineering graduate from the class of '78, at Sheffield Polytechnic – yes, 1978! Think about it, no PCs, no mobile phones, DEC PDP-8 minicomputers with paper tape and punched cards and only the very earliest microprocessors to play with.

Anyway, the recent rediscovery of your magazine has been a welcome distraction in my world, which these days, is otherwise devoid of anything remotely electronic.

Will you be taking the *Teach-In* series in the direction of control theory and Laplace transforms? (Hmm, perhaps not!)

Keep up the good work!

PS Do you know anyone who wants to buy a second-hand Spirule?

Chris Hodgson, Rochester

I'm pleased to hear that EPE *in general and Teach-In in particular has restored and maintained your interest in electronics. I too was a control engineering student, but of a slightly later vintage – mid 80s. However, I do have a Spirule, although I never got to use it that much.*

For younger readers and those not familiar with control theory, a spirule was a clever mechanical device for adding angles (and other calculations) which are useful when designing feedback systems – especially if you don't have access to a computer with relevant software. An interesting history of this device is available at: ***www.spirule.com/BirthofSpiruleCompany.pdf***

Simple Voltage Switch For Car Sensors

Dear Editor
I have just completed building John Clarke's *Simple Voltage Switch For Car Sensors* constructional project (*EPE*, May 2011). (Incidentally, I sourced the components for this project as a kit.)

The finished project works well and is very pleasing. However, I have found that it has one minor shortcoming. There is very little switch-off hysteresis available at low trigger voltages in the L/H trigger mode.

This project has lots of applications in cars, but also has the capability of being utilised in any application where 12V DC

is available. Consider an application where the unit is to be triggered, by a slowly varying input voltage, at a relatively low signal level of 0.6V. As a result of the voltage divider acting at the signal input, the trigger voltage in this situation, as set by VR1, is required to be as low as 0.3V.

On inspection of the circuit diagram it can be seen that, (with VR1 set to 0.3V, VR2 wound so that it has zero effective resistance and op-amp, IC1a triggered with its output saturated close to the zero volts supply rail), the voltage dropped across D3, a standard 1N4148 signal diode, is so low that the current conduction through D3 and the 10k resistor is insufficient to produce a significant amount of hysteresis. In fact, in this situation when I measured the non-inverting input (Pin 3) of IC1a I found that it had been pulled lower by only about 10mV. That is to say only about 10mV of hysteresis had been produced. This makes things quite critical.

To alleviate this problem, I modified the circuit by replacing D3 with a Schottky diode which, with its low forward current present in this circuit setup, has a lower nominal forward voltage drop of only 0.15V. As a result of this diode substitution, I found that, with 0.3V still set on VR1, the maximum available hysteresis had increased to about 125mV, thus improving circuit operation by reducing the likelihood of relay chatter at a lower trigger level when a slowly varying input signal is present.

Consider just one more measurement example. For an input signal trigger threshold of 1.0V, (ie, 0.5V set as the trigger level on VR1) I measured a maximum of approximately 95mV of hysteresis available with the specified 1N4148 diode installed, whereas with the replacement Schottky diode, the maximum available hysteresis increases to about 285mV.

I would be interested to hear what John Clarke's thoughts are on this minor modification to his circuit design.

While I am putting pen to paper (or fingers to keyboard!), I would just like to mention that I have been aware of some light controversy in the past on *Chat Zone* concerning *EPE's* policy of publishing constructional projects which have previously been published in *Silicon Chip*. I would like to voice my support and encouragement for the staff at *EPE* in continuing with this policy, as I find these projects to be of an extremely high calibre and contribute much value to our quality magazine. Like many other electronics enthusiasts, I have learned a great deal over the years from *Silicon Chip* contributors such as John Clarke, Jim Rowe and Mauro Grassi, and I hope that their continued input will enable us to carry on learning from them in the future. Keep up the good work at *EPE*!

Chris Hinchcliffe, Dorset

It is always worth considering the Schottky diode and its lower voltage drop. As Chris points out, it can be especially useful in low voltage measurement and measurement applications.

I'm delighted you support our policy of using Silicon Chip material – you are correct, the projects they produce are of a very high quality.

EPE June 2011: Motor Speed Controller – errors

Dear Editor

Is there an error in the value of one of the resistors in the motor speed controller current monitoring? The text says there are two 10k resistors to drop the 1.2V (48A × 0.025Ω) down to 0.6V into the base of transistor Q4. This makes sense. But Fig.9, Fig.10 and the parts list all indicate a 100kΩ resistor between the base of Q4 and 0V. This would mean that the limit would (theoretically) be in excess of 500A, so unlikely to ever operate!

Dave Reeves, by email

John Clarke replies:

The 100kΩ resistor from base to 0V for Q4 is correct. The use of 10kΩ was from an earlier version of this project and we neglected to change that part of the text. The text should be revised to reflect the change from a 10kΩ resistor to a 100kΩ resistor.

The resistance change reduces the voltage divider effect from 0.5 for a 10kΩ resistor to 0.91 when a 100kΩ resistance is used. This divider works in conjunction with a 10kΩ resistor connecting Q4's base to the current sense resistance.

Voltage from the current sense resistance is therefore reduced by 0.91. (calculated as 100kΩ divided by (100kΩ plus 10kΩ)) at Q4's base. Current limit will therefore occur at 26.4A when there is 0.66V across the 0.025Ω current sense resistance. The 0.66V is divided down by 0.91 to deliver 0.6V at Q4's base.

The relevant paragraph in the article should have read as follows:

Current monitoring

R1 is a used to monitor the current flow through the motor and IGBT (Q1). Transistor Q4 directly monitors the current via a voltage divider comprising 10kΩ and 100kΩ resistors. At about 26.4A, there is 0.66V across R1 and the resistive divider reduces this to 0.6V at Q4's base. The transistor conducts and shuts down the PWM comparator (IC1b) to disconnect drive to the IGBT. Thus, Q4 provides for transient current limiting.

John Clarke

Quack quack!

Dear Editor

Bella, aged three, was given a small plastic duck for her birthday. Every time she shakes it, the whole duck lights up and flashes red and white for three seconds. (Bella's great-grandmother bought the small plastic duck for 85p from The Toy Box, Wharf St, Godalming – **www.thetoyboxgodalming.co.uk**)

No prizes for guessing that inside the duck are two LEDs. Intrigued to find out exactly how it worked, I obtained a duck for myself – well, two actually, one to dissect and one to play with.

Inside there is a transparent plastic sphere of diameter 25mm. And inside the sphere is a small piece of PCB holding a stack of three watch batteries (giving 4V), two LEDs and a blob of material encasing what must be a timer.

A little spiral spring slants up from the PCB. When the duck is shaken, the spring flexes, its tip touches the PCB and sets the LEDs flashing.

Bella loves it, banging her duck down on the table to make it light up. There were no toys like this when I was aged three.

Murray Ward, by email

Interesting! Thank you for that explanation, and I'm pleased to hear Bella's duck was not sacrificed in your experiments.

Net Work

Alan Winstanley

TODAY, the mobile phone is the focus of all that's new in convergent internet-based technologies. Over the years it's been hard not to notice the inexorable slide towards mobile communications – gone are the days of being tethered to a laptop or PC for email and web.

Facebook made content management easy and eliminated the problems of managing a personal website. It was soon to be at the heart of social networking. A colleague uploaded onto Facebook photos and video clips of his holiday in Vietnam the day they were taken. Many such applications can be handled on a mobile phone.

Google's free Gmail was another revelation, offering convenience and so much disk space as to make the problem of archiving email forgettable. Google also offers simple template-driven websites (**http://sites.google.com**) which might suit families, local groups or clubs and could be used for company Intranets.

Mobile content is king

Still on a mobile theme, YouTube allows users to upload their own video clips and it contains many gems if you care to spend time searching (eg, an *EPE Chat Zone* user pointed to some fascinating footage on how Mullard valves – vacuum tubes – were made.) Old music videos, techie films, vintage TV ads and more are all there, and can be viewed on a suitably equipped mobile by going to **http://m.youtube.com**.

For many, turning to a mobile phone for answers is a complete no-brainer. Simply Google or Bing for something on a phone (eg, 'liquid smoke' food flavouring, which I googled discretely during a BBQ: I then skipped the burgers!) and you'll get links galore, with map location details, directions, local reviews, photos and more: any amount of information all dished up on a plate. Link it to GPS and a built-in digital camera and you need never be lost again. Sending a 'Tweet' or updating Facebook while on the move are easier than ever thanks to a plethora of mobile apps. for iPhones, Windows Smartphones and Android-based mobiles.

Earlier this year, Nokia decided to align with Windows Mobile, bringing Microsoft's Bing search and Nokia Maps to the Nokia mobile. Google is also experimenting with allied technologies, including postal address and voice recognition. A comprehensive and never-ending listing of Google's various enterprises is at **http://en.wikipedia.org/wiki/List_of_Google_products**. Always-on mobile video communications only lack the network coverage and bandwidth at the moment, and the time will come when a camera-phone automatically recognises its owner using face and voice recognition. As Google said about its Calendar scheduler events service, 'All this for free? Yep.'

QRStuff is a great online resource to help produce barcodes

2D or not 2D

We're all familiar with striped barcodes found on almost every consumer product. An optical scanner reads the stripe's reflections to decode its product code, and then a look-up table is checked to find the price and description. Simple EAN barcodes only contain details of the manufacturer, their product code and a check digit, nothing else. In the UK, product barcodes are controlled by GS1 (**www.gs1uk.org**).

Increasingly, we're seeing graphics containing square black pixels on a grid – maybe on a poster or in an advertisement. They are the next generation barcode that can be scanned by a suitably-equipped mobile phone.

Known as 2D or QR/Quick Response codes, instead of simple stripes that are read forwards or backwards, 2D hold a two-dimensional grid of pixels, offering many more permutations. You can have great fun with them, as they can encode all sorts of data, from plain text to website addresses, SMS text – almost anything. Suddenly, you have a whole new way of exchanging simple information – perfect for 2D-equipped mobile phones. Take a look at **www.qrstuff.com** to create your own 2D barcodes that can be emailed or printed out. You can also print them onto sheets of labels.

You'll have to search around for decent software for your phone – some are listed at **http://tinyurl.com/byk4wg**. These are untested by the writer and registration may be required, and you will undoubtedly have to experiment to find a product that's right for your compatible phone. Quickmark offers a highly effective 2D reader for PC users which has screen capture or drag and drop, or use your webcam as a QR code reader. Register and download a version free for personal use from **www.quickmark.com.tw**.

Mobile phones have more interesting things up their **sleeve**: using them for micro-payments such as car parking or vending machines is not a new concept, though it's a long time coming to the West. Near Field Communications (NFC) is a Bluetooth-like short distance RF system that will let customers 'pay' for an item or a ticket with the wave of a mobile phone. Devices from Samsung and Nokia promise to bring us this cashless technology, and gone will be the days of feeding coins into a ticket machine. That's the great thing about electronics – there's always something new coming around the corner.

You can email me at: **alan@epemag.demon.co.uk** or write to the Editor for possible publication in *Readout* at **editorial@wimborne.co.uk**.

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COMPUTING AND ROBOTICS

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Owen Bishop

This is a project book and guide for anyone who wants to build and design robots that work first time.

With this book you can get up and running quickly, building fun and intriguing robots from step-by-step instructions. Through hands-on project work, Owen introduces the programming, electronics and mechanics involved in practical robot design-and-build. The use of the PIC microcontroller throughout provides a painless introduction to programming – harnessing the power of a highly popular microcontroller used by students, hobbyists and design engineers worldwide.

Ideal for first-time robot builders, advanced builders wanting to know more about programming robots, and students tackling microcontroller-based practical work and labs.

The book's companion website at http://books.elsevier.com/companions/9780750665568 contains: downloadable files of all the programs and subroutines; program listings for the Quester and the Gantry robots that are too long to be included in the book.

366 pages **Order code NE46** **£26.00**

NEWNES INTERFACING COMPANION
Tony Fischer-Cripps

A uniquely concise and practical guide to the hardware, applications and design issues involved in computer interfacing and the use of transducers and instrumentation. Newnes Interfacing Companion presents the essential information needed to design a PC-based interfacing system from the selection of suitable transducers, to collection of data, and the appropriate signal processing and conditioning.

Contents: Part 1 – Transducers; Measurement systems; Temperature; Light; Position and motion; Force, pressure and flow. Part 2 – Interfacing; Number systems; Computer architecture; Assembly language; Interfacing; A to D and D to A conversions; Data communications; Programmable logic controllers; Data acquisition project. Part 3 – Signal processing; Transfer function; Active filters; Instrumentation amplifier; Noise; Digital signal processing.

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THEORY AND REFERENCE

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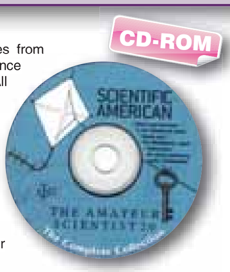

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OSCILLOSCOPES – FIFTH EDITION
Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models are available.

This handy guide to oscilloscopes is essential reading for anyone who has to use a 'scope for their work or hobby; electronics designers, technicians, anyone in industry involved in test and measurement, electronics enthusiasts . . . Ian Hickman's review of all the latest types of 'scope currently available will prove especially useful for anyone planning to buy – or even build – an oscilloscope.

The contents include a description of the basic oscillscope; Advanced real-time oscilloscope; Accessories; Using oscilloscopes; Sampling oscilloscopes; Digital storage oscilloscopes; Oscilloscopes for special purposes; How oscillocopes work (1): the CRT; How oscilloscopes work (2): circuitry; How oscilloscopes work (3): storage CRTs; plus a listing of Oscilloscope manufacturers and suppliers.

288 pages **Order code NE37** £36.99

UNDERSTANDING ELECTRONIC CONTROL SYSTEMS
Owen Bishop

Owen Bishop has produced a concise, readable text to introduce a wide range of students, technicians and professionals to an important area of electronics. Control is a highly mathematical subject, but here maths is kept to a minimum, with flow charts to illustrate principles and techniques instead of equations.

Cutting edge topics such as microcontrollers, neural networks and fuzzy control are all here, making this an ideal refresher course for those working in Industry. Basic principles, control algorithms and hardwired control systems are also fully covered so the resulting book is a comprehensive text and well suited to college courses or background reading for university students.

The text is supported by questions under the headings Keeping Up and Test Your Knowledge so that the reader can develop a sound understanding and the ability to apply the techniques they are learning.

228 pages **Order code NE35** £36.99

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FULL COLOUR COMPUTING BOOKS

HOW TO FIX YOUR PC PROBLEMS — R.A. Penfold

What do you do when your laptop or desktop stops working properly. Do you panic, try to find the answer on the page of fault finding tips you may find at the back of the manufacturers manual. Or do you spend hours trying to get through to a telephone helpline or waste even more time waiting for an email reply from a helpdesk.

Well help is now at hand! This book will assist you in identifying the type of problem, whether it's hardware, software or a peripheral that is playing up? Once the fault has been identified, the book will then show you how to go about fixing it. This book uses plain English and avoids technical jargon wherever possible. It is also written in a practical and friendly manner and is logically arranged for easy reference.

The book is divided into four main sections and among the many topics covered are: Common problems with Windows Vista operating system not covered in other chapters. Also covers to a lesser extent Windows XP problems. Sorting out problems with ports, peripherals and leads. Also covers device drivers software and using monitoring software. Common problems with hard disc drives including partitioning and formatting a new drive. Using system restore and recovering files. Also covers CD-ROM and Flash drives. Common problems with sound and video, including getting a multi-speaker system set up correctly.

An extremely useful addition to the library of all computer users, as you never know when a fault may occur!

Printed in full colour on high quality non-refective paper

128 pages **Order code BP705** £8.49

AN INTRODUCTION TO WINDOWS VISTA — P.R.M. Oliver and N. Kantarris

If you have recently bought a new desktop or laptop it will almost certainly have Windows as its operating system. Windows Vista manages the available resource of a computer and also 'controls' the programs that run on it.

To get the most from your computer, it is important that you have a good understanding of Vista. This book will help you acheive just that. It is written in a friendly and practical way and is suitable for all age groups from youngsters to the older generation. It has been assumed that Vista is installed and running on your computer.

Among the numerous topics explained are: The Vista environment with its many windows. How to organise your files, folders and photos. How to use Internet Explorer for your web browsing. How to use Microsoft Mail for your emails. How to control your PC and keep it healthy. How to use Vista's Accessibility features if you have poor eye sight or difficulty in using the keyboard or mouse. And much more besides....

With the help of this book you will easily and enjoyably gain a better understanding of Microsoft's amazing Windows Vista operating system.

Printed in full colour on high quality non-refective paper

120 pages **Order code BP703** £8.49

COMPUTING WITH A LAPTOP FOR THE OLDER GENERATION — R.A. Penfold

Laptop computers have rapidly fallen in price, increased in specification and performance and become much lighter in weight. They can be used practically anywhere, then stored away out of sight. It is therefore, not surprising that laptop sales now far exceed those of desktop machines and that they are increasingly becoming the machine of choice for the older generation.

You may want to use your laptop as your main computer or as an extra machine. You may want to use your laptop on the move, at home, at work or on holiday. Whatever your specific requirements are, the friendly and practical approach of this book will help you to understand and get the most from your laptop PC in an easy and enjoyable way. It is written in plain English and wherever possible avoids technical jargon.

Among the many topics covered are: Choosing a laptop that suits your particular needs. Getting your new computer set up properly. Customising your computer so that it is optimised for your particular needs. Setting up and dealing with user accounts. Using the Windows 'Ease of Access Center'. Optimising the life and condition of your battery. Keeping the operating system and other software fully up-to-date. Troubleshooting common problems. Keeping your computer and data safe and secure. And much more besides...

Even though this book is written for the older generation, it is also suitable for anyone of any age who has a laptop or is thinking of buying one. It is written for computers that use Windows Vista as their operating system but much will still apply to Windows XP machines.

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AN INTRODUCTION TO EXCEL SPREADSHEETS — Jim Gatenby

The practical and friendly approach of this book will help newcomers to easily learn and understand the basics of spreadsheets. This book is based on Microsoft's Excel 2007 spreadsheet, but much of the book will still apply to earlier versions of Excel. The book is written in plain English, avoiding technical and mathematical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.

Among the many topics explained are how to: Install the software. Use the exciting new features of Excel 2007. Create and use a spreadsheet. Enter, edit and format text, numbers and formulae. Insert and delete columns and rows. Save and print a spreadsheet. Present the information on a spreadsheet as a graph or chart. Manage and safeguard Excel files on disc. Use Excel as a simple database for names and addresses.

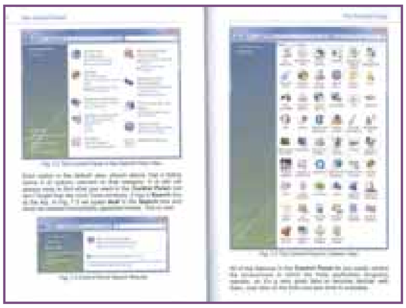
This book will help you to quickly gain confidence and get to grips with using spreadsheets. In fact, you will wonder how you ever managed without them.

Printed in full colour on high quality non-reflective paper.

118 pages **Order code BP701** £8.49

AN INTRODUCTION TO DIGITAL PHOTOGRAPHY WITH VISTA — R.A. Penfold

The friendly and practical approach of this book will help newcomers to digital photography and computing to easily learn the basics they will need when using a digital camera with a laptop or desktop PC. It is assumed that your PC uses Windows Vista, however, if it is a Windows XP machine the vast majority of this book will still apply. The book is written in plain English, avoiding technical jargon and all illustrations are in full colour. It is suitable for all age groups from youngsters to the older generation.



Among the many topics explained are how to: Understand the basic features of a digital camera. Transfer photographs from your digital camera to your computer. View your photographs. Save, sort and file your photographs. Manipulate, crop and carry out simple corrections to your photographs. Copy your photographs on to CD or DVD. Print your photographs. Share images with family and friends anywhere in the world by email or with an online album.

This book will help you quickly get to grips with, gain confidence and expand your horizons in the fascinating hobby of digital photography.

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120 pages **Order code BP700** £8.49

PROJECT BUILDING

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

Temporarily out of print

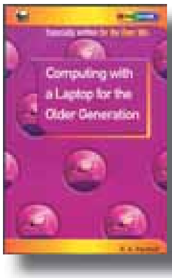
BUILDING VALVE AMPLIFIERS
Morgan Jones

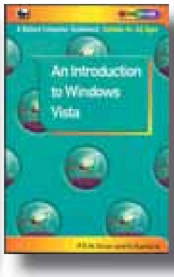
The practical guide to building, modifying, fault-finding and repairing valve amplifiers. A hands-on approach to valve electronics – classic and modern – with a minimum of theory. Planning, fault-finding, and testing are each illustrated by step-by-step examples.

A unique hands-on guide for anyone working with valve (tube in USA) audio equipment – as an electronics experimenter, audiophile or audio engineer.

Particular attention has been paid to answering questions commonly asked by newcomers to the world of the vacuum tube, whether audio enthusiasts tackling their first build, or more experienced amplifier designers seeking to learn the ropes of working with valves. The practical side of this book is reinforced by numerous clear illustrations throughout.

368 pages **Order code NE40** **£29.00**





PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

HOW TO BUILD A COMPUTER
R.A. Penfold

To build your own computer is, actually, quite easy and does not require any special tools or skills. In fact, all that it requires is a screwdriver, pliers and some small spanners rather than a soldering iron! The parts required to build a computer are freely available and relatively inexpensive.

Obviously, a little technical knowledge is needed in order to buy the most suitable components, to connect everything together correctly and to set up the finished PC ready for use. This book will take you step-by-step through all the necessary procedures and is written in an easy to understand way. The latest hardware components are covered as is installing the Windows Vista operating system and troubleshooting.

320 pages **Order code BP591** **£8.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

Temporarily out of print

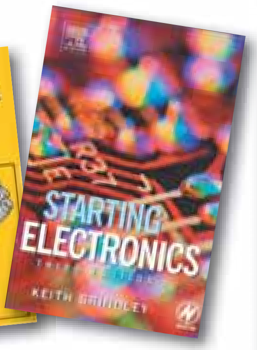
THEORY AND REFERENCE

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£5.49**



STARTING ELECTRONICS
Third Edition
Keith Brindley

A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

288 pages **Order code NE42** **£15.99**

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Printed circuit boards for most recent *EPE* constructional projects are available from the *PCB Service*, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. Double-sided boards are **NOT plated through hole** and will require 'vias' and some components soldering to both sides. All prices include VAT and postage and packing. Add £1 per board for airmail outside of Europe. Remittances should be sent to **The PCB Service, Everyday Practical Electronics, Wimborne Publishing Ltd., 113 Lynwood Drive, Merley, Wimborne, Dorset BH21 1UU. Tel: 01202 880299; Fax 01202 843233; Email: orders@epemag.wimborne.co.uk. On-line Shop: www.epemag.com**. Cheques should be crossed and made payable to *Everyday Practical Electronics* **(Payment in £ sterling only)**.

NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail. Back numbers or photocopies of articles are available if required – see the Back Issues page for details. WE DO NOT SUPPLY KITS OR COMPONENTS FOR OUR PROJECTS.

Please check price and availability in the latest issue. A large number of older boards are listed on, and can be ordered from, our website.

Boards can only be supplied on a payment with order basis.

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For editorial address and phone numbers see page 7

Next Month

Build a high-quality stereo DAC for superb sound from your DVD player

Do you listen to CDs via your DVD player? Is your listening pleasure suffering from the DVD player's average sound quality? Worse still, do you get buzz and hum problems when hooked up to your hifi? If so, you need this high-quality stereo digital-to-analogue converter (DAC) – it will transform your listening experience to first-class sound and zero hum.

Using a wideband O2 sensor in your car – Part 1

This wideband controller is designed to be used with a Bosch Wideband LSU4.2 oxygen sensor and our wideband sensor display to accurately measure air/fuel ratios over a wide range – from rich to lean. Use it for precise engine tuning!

Deluxe 3-channel UHF Rolling Code Remote Control – Part 2

In this, the August issue we introduced our new high security remote control and completed both the receiver/relay driver and transmitter. Next month, we'll put it all together and get the two parts talking to each other – *securely*!

Recycle It!

Six fun uses for salvaged parts – electronic fun for free!

Teach-In 2011 – Part 11

You can't keep a good idea down, and Mike and Richard Tooley have provided us with one more instalment of *Teach-In 2011*! Next month, we'll round off the series with some fun revision and a selection of electronic projects that you can build and test using Circuit Wizard.

SEPTEMBER '11 ISSUE ON SALE 11 AUGUST Content may be subject to change

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